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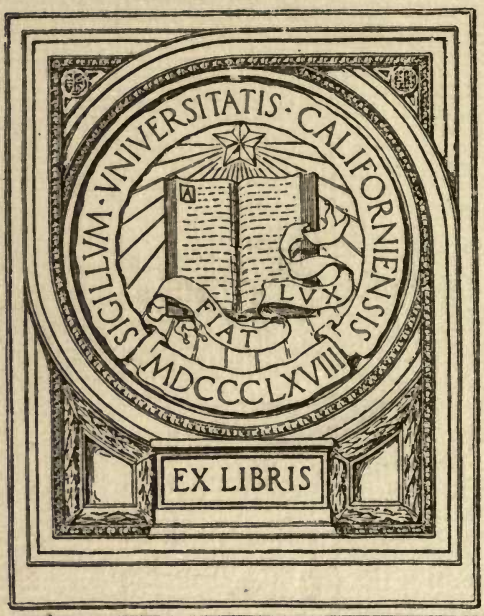

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CORNFLOWERS.

WONDERS OF PLANT LIFE

BY

S. LEONARD BASTIN

With 40 Plates from Photographs by
THE AUTHOR, and Eight Autochromes
by H. ESSENHIGH CORKE, F.R.P.S.

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I

THE ASSERTIVE PLANT

On this crowded earth, one of the chief problems which confront the individual plant is that of finding room to grow at all. Every available space is so thickly tenanted that it is only the very sturdy, or the very ingenious, subject that can hope to hold its own in the great struggle for a position. The appearance of the June meadows is not in the least suggestive of strife, yet on every foot of the ground there has been waged a battle that has decided the fate of a countless array of units. The tall grass heads, and the graceful Moon Daisies, are but the surface representatives of a densely populated world beneath, the inhabitants of which are so closely packed together that it is pardonable to wonder how they can exist at all. Indeed, the overcrowding is such that not a trace of the brown earth is visible in the compact turf formed by the innumerable

plants. It is possible to realise how keen must have been the competition for a place when we remember that for each plant which has come to perfection several score will have gone down in the struggle.

Perhaps some of the most aggressive plants in the capturing of positions are those with subterranean stems, which run along under the soil, sending up shoots at intervals. Not a few of the grasses are marvellous instances of how much space a single plant may cover. The maritime grass *Psamma arenaria,* so common on our coast sand-hills, spreads over a huge area of ground, as may be proved by pulling up one of the tufts. It will be found that the long stem may be traced back for several feet to the parent plant. In a very similar manner does the great Bracken Fern thrust out its rhizomes, or underground stems, in all directions, and in this way occupy the ground to the exclusion of almost everything else. In a very large number of cases, however, the stems are simply procumbent, running along on the surface of the soil. The Speedwells, the Potentillas and the Strawberries are in this way able to monopolise the situation.

In one summer a sturdy specimen will succeed in rooting its leaf joints in dozens of places ; these

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THE POTENTILLAS COVER IN A LARGE AREA
BY MEANS OF THEIR CREEPING STEMS.

THE BRAMBLE IS ALWAYS ABLE TO CHANGE ITS SHOOTS INTO ROOTS
SHOULD A FAVOURABLE POSITION PRESENT ITSELF.

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plantlets are doubly strong in that they are not only rooted on their own account, but are still in receipt of assistance from the parent. The chances of seedlings whose lot has been cast near to one of these pushful species are doubtful in the extreme. It is a version, in the vegetable world, of the old story of the small tradesmen with single shops struggling against the great company with its hundred branches, each one of which is supported from a central establishment. Still further to the advantage of the spreading plant is the fact that if any of the sections should become detached, these enter upon the scene as new individuals, quite capable of representing the race on their own account. A large number of perennials adopt this mode of increase in addition to seed-bearing, and these are to be numbered among the most successful of plants.

There can be no doubt that the large number of species which have resorted to climbing methods have been induced to do so by the ever-pressing need for room. That this enterprise has not been in vain is a commonplace fact of the country-side, for it is the Brambles, the Honeysuckles, and the Bryonies which have long since captured the hedges for their very own. Right down in the darkness at the centre of the hedge we may

find the rooting-place of these plants, in situations where nothing but a subject that could grow yards up towards the light would possibly be able to exist.

The different methods adopted by the climbing plants to get up in the world are as varied as they are ingenious. Perhaps the most common is that to be seen in the case of the twining species, which by means of their stems twist themselves round a support. Some of these plants, such as the Hop, invariably turn from left to right; whilst others, of which the Bean is a typical example, travel in an opposite direction. The constancy with which each species adheres to its particular habit of growth is very remarkable; no coercion will induce the stem to alter its natural course.

A very interesting experiment may be conducted with a common Scarlet Runner Bean plant to illustrate the climbing methods of the species. A young seedling should be secured which has just developed its second pair of leaves. At this stage the short stem is very nearly upright, but as it develops it becomes too slender to support itself. Now comes into operation that curious tendency on the part of climbing plants called circumnutation. This consists in a ceaseless search

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NASTURTIUMS.

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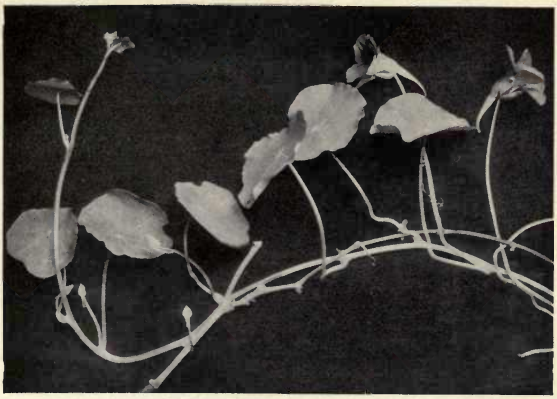
for a support ; round and round the stem travels, reaching out farther and farther every time the circle is complete. On a warm day the stem of the Bean goes round at a wonderfully rapid rate. In one case the tip of the shoot traversed a circumference of two feet in a couple of hours, showing that the rate was an inch in five minutes —no mean performance for a plant.

When the circumnutation of the Bean has been fully observed, it is instructive to place a support within reach of the shoot. This should be upright, seeing that as a general rule the twining plants are not able to climb save up a nearly perpendicular object. The attachment to the stick is a matter which is very quickly accomplished, for a few minutes after the shoot is actually touching the tip commences to curl round. As soon as the hold is securely accomplished, the manner of growth changes into the spiral twining by means of which the stem will advance up the support. This is probably related to, if not identical with, the process of circumnutation. The passage of the Bean shoot up the support is now very rapid, and on a close summer night will be as much as two inches in the twelve hours.

Next in importance to the twining plants are those which clamber up by means of tendrils.

These organs are among some of the most wonderful in the plant world. One interesting British plant producing tendrils is the White Bryony, a common hedgerow species. In this case the climbing organs are large, sometimes extending to four or five inches in length. The means by which the tendrils secure a hold, and then twist themselves into the permanent position, offer a peculiarly fascinating study. Prior to their attachment to any object, the processes maintain a curious swaying movement, which must increase the probability of their coming into contact with a support. Directly the tip of the tendril is within reach of some object it begins to entwine itself without delay. In the space of a few minutes, supposing the conditions to be favourable to rapid growth, the slender thread has started to encircle the support. The underlying cause seems to be partly in the stimulating influence induced by the light rubbing of the under side of the tendril against the object. When the tendril is at its greatest period of activity it may be induced to curl round almost any object which is offered to it.

A pencil, or the little finger, passed gently along the inner side of the organ will cause it to twine around the support, the slight rubbing



THE NASTURTIUM CLIMBS BY MEANS OF ITS LEAF-STALKS.

BLACK BRYONY CLIMBING UP BRACKEN.

making the movement a good deal more rapid than is normally the case. As a rule, the tendril is not content with merely looping itself once round the support, but, in order to make quite sure that there can be no slipping away, doubles or trebles the circles. When the attachment has been rendered quite secure, the strange spiral twisting comes into operation. As a rule, the turning goes on in one direction for half the length of the tendril, and in an opposite way for the remaining half.

This coiling business is very interesting to watch, and is started with the formation of a small crank-like process, which continues to make complete revolutions, swinging downwards and upwards with the greatest regularity. As it does this the tendril is, of course, coiled on either side of the bent portion, in one direction on one side, and in an opposite direction on the other side. When the coiling is completed the small crank-like part will appear as a little straight section between the two spiral portions. At times it is to be noticed that tendrils will develop several series of spirals, and thus there may be two or three of the alternating portions. The spiral conformation, of course, very much tends to strengthen the organ, whilst at the same time it secures to it a certain

springiness that will allow a "give" when the plant strains in rough weather.

Not a few plants climb upwards by pressing into service their leaf-stalks; of these, the garden Nasturtiums and the Wild Clematis are examples. Both these species, particularly the latter, contrive to rise to a considerable height by twisting their leaf-stalks round the nearest support. The Ivy has resorted to a still more curious method, and is able to attach its stems to trunks of trees and other supports, by means of its adventitious roots which are so freely produced. These processes serve the double office of climbing organs and also as means of imbibing water; indeed, in very moist weather the ivy will often send out quantities of the white filaments on the side of the stem which is not attached to the support. Finally the common Bramble scrambles upwards by means of the bent hooks with which its stems abound. These enable the plant to catch hold of any surrounding objects, so that it easily brings its leaves into the lighter position.

It is not only as a climbing species that the Bramble is remarkable; in another way the plant offers a curious instance of resourcefulness. Every wayside patch is adorned with its blackberry bushes, and one of the reasons for this

A SPECIES OF HYACINTH WHICH DROOPS ITS LANCE-LIKE LEAVES OVER THE SURROUNDING SOIL AND SO DISCOURAGES OTHER PLANTS.

plenitude of Brambles is to be found in a strange habit which the plant possesses. When, as is so often the case, the Bramble is growing over a pile of stones or rambling up a rough rock wall, it is seen that the plant takes root all over the place. If the lusty shoots which are sent out in such profusion come into contact with a little vegetable mould that may have collected between the chinks of two stones, or even rest for any length of time upon the ground, the tips quickly lose their original character. All the features of a growing shoot vanish, and the point, becoming clubbed, eventually sends out roots. Thus a fresh hold has been secured by the aggressive Bramble.

The budding propensities of certain plants are very interesting in the part which they play in helping the species to spread over the surface of the ground. An Indian evergreen shrub belonging to the House-leek family produces leaves which at every notch in the border bear an embryo bud. The species, which is named *Bryophyllum calycinum*, can literally produce a score or more of baby plants from any of its leaves. If a leaf is thrown down on the soil the buds quickly develop into perfect little specimens. A North American fern is perhaps even more curious. This is a

species of Hart's Tongue (*Scolopendrium*), and has been called the "Jumping Fern," on account of its strange habit. As a rule, the buds of this species are produced at the tip of its lance-shaped fronds. These fronds, being very long and slender, trail over until their tips touch the ground, when, if the soil be in a moist condition, roots quickly form on the under surface at the point of contact, and from the upper surface new fronds arise.

It is certain that plants do all in their power to discourage their neighbours. The struggle for a place is so severe that it is a case of everyone looking out for himself. It is to be observed that many species have a striking tendency to cover in as much space as is possible with their leaves. Perhaps one of the chief reasons for the evolution of large foliage is that thereby the subject can more readily hold an unhampered position. In some ways big leaves carry with them great disadvantages; they are readily damaged, whilst a comparatively long while must elapse before they can be replaced. Again, the big surfaces they offer may at times bring about a more speedy evaporation of moisture than is desirable. But to balance all this, the large-leaved plants are never likely to be in difficulties for want of room,

THE HUGE LEAVES OF THE SOUTH AMERICAN GUNNERAS COVER A LARGE AREA.

TO VIEW
ANNOTATED

simply because their overshadowing growth will smother all the adjacent species.

Consider the position of seedlings coming up among the stems of a good-sized Dock. Completely sheltered from the light and air by the great leaves, there is not the slightest chance that they could ever come to perfection. In pulling aside the foliage of any large Dock plant we may find the remains of the unfortunate seedlings which have perished under the sheltering leaves. The British Dock is quite a pygmy beside the great American Gunneras. These plants, which in their appearance are suggestive of vast Rhubarb, produce leaves that are enormous. Borne on long, stout stems, which are at times as much as ten feet in height, the great leaves spread out in a canopy that keeps an immense area of ground in perpetual shade. The shelter which the leaves afford may be realised when it is stated that not infrequently the huge organs are six feet across.

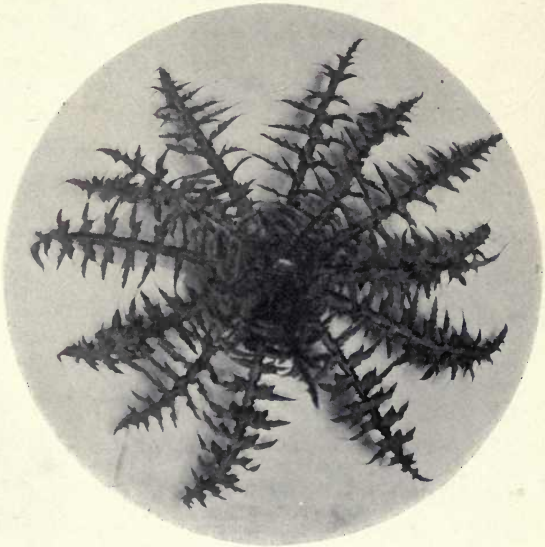
Very much the same kind of thing happens in the world of trees. When one sees the enormous crop of acorns produced by the Oak, and watches the myriads of Sycamore seeds which flutter to the ground in the early autumn, it is difficult to realise how it is that the whole country is not

covered with these trees. A considerable number of the seeds, it is true, are destroyed by the wild animals and birds of the forest, but after all only a small number are accounted for in this way. Probably the majority of the seeds germinate, and even grow into little plants during the first few weeks of mild spring weather, before the forest is clad with its summer foliage. But it is only a very few which get beyond the start, for under the dense shade thrown by the clustering leaves above no development is possible; and more often than not it is the spreading branches of the parent tree which bring about the destruction of its own offspring.

Many plants which flower in the late spring might easily be smothered out of existence had they not been enabled to make special provision against such a contingency. With the arrival of the really warm weather the countless seeds which have been lying dormant all the winter start to germinate. In this connection a curious phase in the life of the Primrose is the habit of "flopping" its foliage after blooming time. As one of the earliest of our spring-flowering species, the Primrose has a good start over the rank-growing weeds which will not put in an appearance until the early summer. But as the last of

THE PRIMROSE,

Which flowers in the spring, would be in great danger of being overwhelmed by the early summer growth, were it not able to smother the surrounding vegetation by "flopping" its leaves.



THE PRETTY PATTERN FORMED BY THE DWARF PLUME THISTLE.

the pale yellow flowers dies, the plant enters a critical period of its life; it is in grave danger of being smothered out of existence. At this time, however, a very marked change comes over the bearing of the foliage; the leaves lose their more or less erect habit and "flop" over on to the ground, encircling the crown of the plant. In this way, the menacing army of seedlings which will come with the end of May are prevented from making any headway in close proximity to the plant. If it were not for this provision there can be little doubt that the Primrose would be almost choked by the rank-growing weeds which are on every side. Many of the late spring-blooming varieties of the smaller Hyacinths send out a profusion of drooping leaves just at flowering time. These will make it quite certain that the plants will not be troubled by any near neighbour.

In the case of a large number of common weeds the habit of growth, which has been referred to as "starring," is a very pronounced feature. As is well known, the matter of leaf arrangement in the plant has been devised on definite lines, and with a mathematical precision. Each leaf has its exact place, and when development is unhindered by any restraining influence the exactitude of the system becomes very apparent.

In a well-developed Dandelion, where the growth is quite free, a most perfect rosette is often formed, each leaf falling into its place with a wonderful regularity. The little Shepherd's Purse, a very common cruciferous weed, which sends its clusters of dainty white blossoms up to a considerable height, employs the greater part of its foliage in covering the ground in its immediate vicinity. Examples of this plant will easily spread over a rough circle of land which is as much as nine or twelve inches in diameter. Through the dense, matted growth of leaves formed by these plants, there is little chance that any smaller species could hope to make headway.

The Dwarf Plume Thistle, a plant commonly found in meadows near the coast in the south of England, has proved itself to be a most pernicious weed from the farmer's point of view. The leaf arrangement round the central stem which bears the short-stalked flower, really forms a most attractive pattern, and one which shows plainly by what a rigid code of rules the plant is designed. From the agriculturist's outlook, however, the Dwarf Plume Thistle is anything but a welcome addition to the pasture land.

As a strong-growing perennial, when once the

MANY SPECIES HAVE A HABIT OF "STARRING" OUT, AND IN THIS WAY DISCOURAGE SURROUNDING GROWTH.

plant has secured a hold, its method of "starring" is very prejudicial to the growth of tender grasses and small herbs. None of these less robust plants can possibly make any headway beneath the clinging leaves of the thistle.

II

THE PLANT AND THE SEASONS

THE changes which come over the world of plants with the passage of the seasons are the most distinctive features of the countryside. At the approach of winter the greater number of trees and shrubs, in common with most perennial species, pass into a state of quiescence from which they will not emerge until the arrival of the spring. Such a course is only possible in conditions which involve a cessation of vegetable activity that is practically universal. In the tropical forests the trees are almost without exception evergreen in habit, and it is necessary that they should be so, if they are to hold their own in the fierce struggle for existence. The welfare of the tree depends upon the extent to which it can keep the soil beneath it in a state of dense shade. Underneath the spreading branches the ground is littered with germinating seeds, only waiting for a few rays of sunshine to

enable them to start into a vigorous upgrowth. Should the tree become denuded of its foliage for even a short while, it would soon find itself surrounded by a host of formidable rivals that might threaten its very existence. No such considerations arise in the case of trees growing in temperate climes for at any rate half of the year. In the bitter days of winter there is no fear that the myriads of seeds which lie buried in the soil will start into life. Even should they do so during the first few weeks of warm weather they will scarce have grown into small plants before the branches above them are thick with rustling leaves.

To the lover of Nature every springtime comes with freshness, offering as it does a new opportunity to observe one of the most amazing sights in the whole world. The bare trees, the leafless hedges, and the brown earth are in a few short weeks transformed as by the touch of a magician's hand. So great is the up-rush of life that it is quite impossible to separate oneself from the joyousness of the resurrection. It is interesting to dwell upon the underlying causes which bring about this annual change. The question is one which must often arise—How do plants know the seasons? At first sight it may seem that a

renewal of activity is simply due to the fact that the cold weather is gone; but this does not offer a complete solution of the problem.

In the autumn the conditions are often mild for weeks together, yet the trees do not start into leaf. It may be suggested that it is the increase in the intensity and the amount of sunshine which arouses the plants from their winter slumber. This can hardly be the case with the large number of herbaceous plants with rootstocks inches below the surface of the soil, yet these respond to the call of spring no less readily than the deciduous trees and shrubs. Even more difficult to explain is the behaviour of the aquatic species, such as the Water Lilies. The roots of these plants are buried in mud many feet deep under water—how can they possibly be aware of the arrival of the new season? Yet quite early in the spring these plants begin to stir into activity. Most strange of all in connection with the problem of the plant and the seasons is the story of the Soldanellas, a small species which exists on the lower slopes of the Alps. When the flower stems are in their most active state of growth they release a considerable amount of heat. In this way they will bore a course up through a thick coating of ice and snow to the

SUMMER: SHOWING ALL THE AQUATIC PLANTS ABOVE THE WATER.

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WINTER: ALL THE PLANTS DISAPPEAR BELOW THE WATER.

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light and air above, when by some means, of which we can form little idea, the plant is aware that the spring has arrived. There seems to be something more in the phenomenon than can be explained as mere mechanical cause and effect. Indeed, the sympathy of the plant with the seasons is surely one of those mysteries which are as inscrutable as life itself.

The spring is perhaps the most trying time of the whole year for the plant. Often enough the first few fine days which have given promise of coming summer are followed by rigorous conditions which would more properly belong to the depths of winter. Yet it is very rarely that any serious damage results to the young foliage, even if the dainty leaves have already left the protection of the bud cases. To examine the expanding shoots of the Horse Chestnut, is to find that each leaf is clothed with a downy substance which forms a perfect protection against cold.

In the case of a large number of plants the foliage is not expanded until it is in an advanced stage; leaves rolled up or folded together are more likely to escape damage than those which are open. Another curious phase in the early development of the leaf is connected with the colouring of the tissue. Very young foliage is

often of a reddish tint, a circumstance commonly to be seen in the case of Sycamore and Maple shoots. Crimson patches are also not infrequently seen on the upper surfaces of Hazel leaves. As well, the bud cases of many trees and shoots take on a bright crimson shade in the early part of the year. This is seen to great advantage in the case of the Lime trees. It is believed that this colouring is a protective measure, brought about to prevent an undue loss of heat. It has indeed been proved that the purple tinting on the under side of the Water Lily leaf is due to the presence of a curious pigment called anthocyanin, which has the remarkable property of changing light into heat. By this means the chilling influences of the water are controverted.

It is no hindrance to the enjoyment of the spring day to consider the more immediate cause of the bursting buds and expanding leaves to be seen on every side. This is nothing less than the resumption of the flow of sap—a process which has been almost entirely suspended during the last four or five months. All through the winter, growth on the part of the deciduous trees has been at a standstill, and only sufficient of the vitalising sap has been in circulation to keep the specimen from dying altogether. It must never

WATER LILIES

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be forgotten that when the tree is in its fullest state of activity, there are two very distinct currents of sap—the ascending and the descending flow. The starting into growth of the tree has been compared to the lighting of a lamp. To an extent the developing leaves exercise just that drawing power upon the liquid imbibed by the roots from the soil which the burning wick does upon the oil in the reservoir. This is not a complete explanation of what is really a great mystery, for it must be borne in mind that a very vigorous sap flow starts before the foliage is expanded.

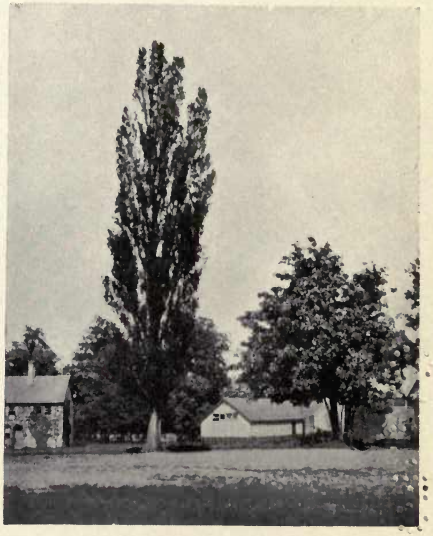
The course which the sap pursues in a typical tree may be briefly outlined. Starting at the root, the fluid is carried upwards through the cells of the newer wood to the upper surface of the leaves. At this stage the sap is really little more than plain water, combined with certain inorganic matter taken from the soil. The force with which the sap rushes upwards is very great, and by way of experiment a vine stem was severed a few feet from the ground in the springtime, and a bladder tied over the cut end. In a short while the bladder was greatly extended, and finally burst, unable to sustain the tremendous pressure of the sap flow. It is not until the passage of the sap along the upper surface of the leaves that the great change

comes in its composition. Exposed to the magical influence of the sun and air, the fluid is completely elaborated. By a process which is not fully understood the inorganic material taken up by the plant from the soil is changed in such a way that it can be assimilated by the tissues of the vegetable. The sap is now very much altered in its consistency. A large proportion of water has been evaporated, and the fluid is thick and rich in nutrient matter. Moreover, it will have acquired certain peculiar properties—in the case of the Oak, for instance, these being of an astringent nature. The course which the sap now pursues will take it along the under side of the leaves, through the new tissue, and so back to the roots again.

All the summer long the leaf lives a life of intense activity, manufacturing a store of food material which will be put aside in various parts of the plant. With the coming of the autumn, however, the vitality of the leaf steadily declines, the sap movements become very slight, and the time has come for the organ to be separated from the tree. So far-seeing is Nature, that the leaf is scarcely developed ere preparations are commenced for the severance of it from the twig. Quite early in the history of the leaf at the point

WINTER.

PROTECTIVE BUD COVERING OF A SYCAMORE TREE.



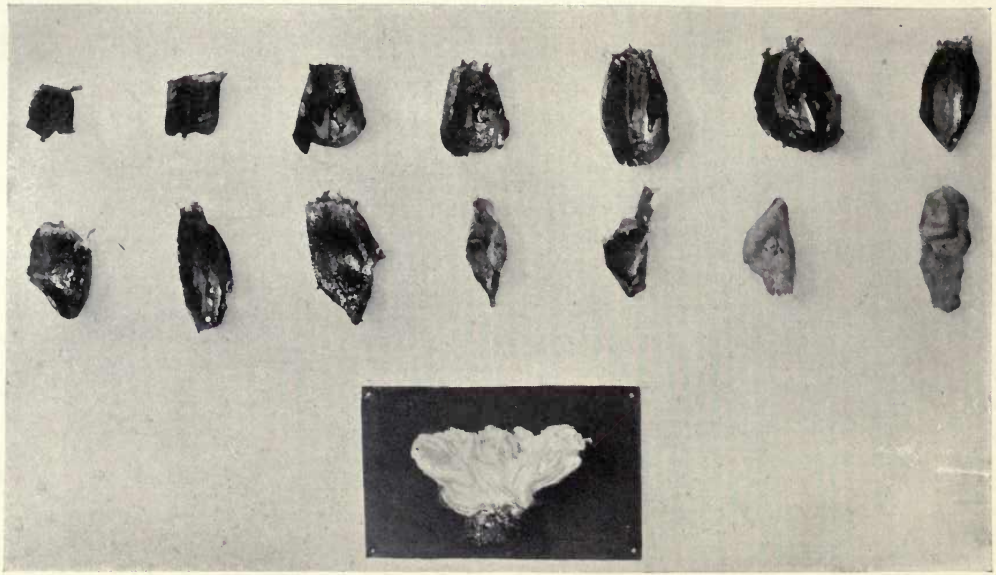
SUMMER.

of union between the stalk and the stem, a special arrangement of cells is formed. This has been called the layer of separation, and consists of a number of cells running at right angles to the tissue of older formation. The greater the age of the leaf the more markedly does the line of separation appear, and as the processes of assimilation begin to slacken and the moisture evaporates, the severance of the organ is only a matter of time. Finally, the presence of organic acids so weaken the cells that the leaf will perhaps fall by its own weight ; in any case the first gust of wind will be sufficient to complete the fracture.

When the stalk has become detached it does not leave a raw and bleeding wound behind, such as would be produced by the forcible pulling of the leaf from the branches. The very layer of cells which brought about the separation has also ensured the welfare of the twig from which the leaf has been removed. A thin veil is spread over the point of cleavage, so that there is never any open surface exposed to the air at all. There are few more beautifully contrived processes in the natural world than this fall of the leaf, with which the tree passes into its winter rest. And so the leaves, often brightly coloured as the result of the chemical change which has taken place in

their tissues, flutter to the ground—there to lie until decomposition gradually changes them into soft mould. In this way a bed of fine rooting material is formed for future generations of seedlings.

It is, indeed, a wrong impression to consider the autumn as simply a time of decay, for much is accomplished at that period by way of preparation for the following spring. Pull a Chestnut bud to pieces just before the tree loses its foliage, and it is possible to distinguish the leaves—on a small scale, certainly, but in a wonderfully perfect condition. Several pairs of leaves may be readily distinguished all packed away in downy material, quite ready for the development which will come with the spring. This being so, the protection of the buds against the rigours of winter is a matter of first importance in the life of the plant. Perhaps one of the most obvious features in our Chestnut bud is the gummy substance coating the exterior, which under the influence of warm sunshine becomes very sticky indeed. This material is most valuable on account of its non-conductive properties, and doubtless plays a large part in shielding the contents of the bud from cold. Apart from this, however, there are several layers of scales which play the chief part in check-



PROTECTIVE SCALES OF CHESTNUT BUD.

ing the penetration of cold to the immature leaves.

Generally speaking, in nearly all trees these scales represent parts of leaves which have been arrested in their development or even have partially died, and have thus become horny in texture. In plants such as the Lilac and Rhododendron the bud scales are modifications of entire leaves, and keep green throughout the winter. In one of our deciduous species, the Wayfaring Tree (*Viburnum Lantana*), the lowest leaves of all act as bud scales, and these, owing to a woolly coating, are able to survive through the winter and finally develop as ordinary foliage leaves.

It is a wise provision which has ordained that the tree should become denuded of its foliage before the winter. This season is a time of rough weather, when the strong gales sweep over the country and threaten to destroy all before them. Any of the large forest trees in full leaf would offer a tremendous resistance to the wind, and, of course, suffer accordingly. Now and again, when a severe summer gale has visited a part of the country which is wooded, it has been possible to gather some idea of the havoc which a strong wind works among trees in foliage. It is interesting to observe that practically all the so-called evergreen trees

which are indigenous to temperate regions produce comparatively small leaves. Of these the great tribe of Conifers are typical, which with their needle-like leaves do not offer serious resistance to the wind.

Apart from the Firs, the trees and shrubs which keep their foliage all the winter produce comparatively small leaves, and these are mostly of specially thickened texture so that individually they may not suffer from wind damage. Round the border of the Holly leaf may be traced a kind of selvedge, formed of thickened layers of cells. This does much to prevent the leaf from being torn in rough weather. The small size of the leaves in the case of these evergreens is also to the advantage of the plant in another way, by preventing snow accumulation. The thick leafy branches of the deciduous trees would provide a lodgment for the falling flakes to such an extent that serious bough breakage would result. The dry particles of snow find little to rest upon in the slender foliage of the Fir or the small, narrow leaves of the Yew.

At all times cold is a great menace to plant life, and a period of severe frost is full of danger to the unprotected vegetable. Yet the low temperature which would threaten to destroy the

CHERRY LAURELS IN WINTER.
The drooping of the foliage during frost is valuable as a protective measure.

plant seems to bring about an alteration in the bearing of the foliage that is valuable as a protective measure. It is seen that during very cold weather many plants droop their leaves, and in this manner prevent a serious loss of natural heat. Most people must have observed how different is the bearing of the Cherry Laurel on a frosty morning to what it is in mild weather. There is little doubt that the leaves would be badly damaged by the cold if they were held out in the normal fashion.

A very considerable number of plants are herbaceous in habit; that is to say, they do not form any woody material which lasts through the winter above-ground. In these cases it is seen that towards the end of the summer there is a decided slackening in the activity of the plant, and finally the circulation of the sap ceases altogether. In fact, all the life of the plant vanishes underground. That there is a very real purpose in this behaviour on the part of the herbaceous species is certain; most of these plants are decidedly tender in habit, and few of them are able to produce stems fitted to cope with the rough weather.

Though there is nothing to be seen above-ground when the herbaceous plant has retired to

rest, there is a very great deal below the surface. The forms taken by roots are very varied, even if we put aside altogether the underground processes such as bulbs, tubers, and rhizomes, which are, after all, only modified stems. In most cases those parts of the plant beneath the surface are to be regarded as storage chambers upon which the specimen will draw when it is called upon to start its spring growth. With some species the amount of energy stored up is very considerable —sufficient to bring the plant to its maturity if moisture is obtainable. Thus it is seen that a Hyacinth will produce leaves and flowers grown in a vase of plain water.

All through the winter millions of seeds have been lying in the earth. These have remained in a state of quiescence, just in the same condition as when they tumbled, brown and ripe, from the parent plant. It is always somewhat of a mystery as to how it is that the seeds are so well planted. By some means or other Nature generally manages to get most of her seeds covered in before the winter arrives. There is little doubt that the earth-worms take on a large share of the work. During the moist autumn weather these creatures work comparatively near to the surface, and their countless upheavals of

soil go a long way towards covering in the seeds. Seed vessels with long appendages, such as those of the Sycamore and Lime, may often be seen pulled down into the soil, having been treated in much the same way that the worms deal with leaves. Acorns, beech-masts and other edible seeds are stored away in holes in large quantities by small animals, such as squirrels and dormice, which inhabit our woods; the majority of them are forgotten altogether by the little creatures, and many a tree must owe its start in life to the efforts of these tiny gardeners. In addition to the work of these animal agents, the heavy rains of autumn must wash many of the smaller seeds into the soil, whilst the shower of drifting leaves will cover up even a larger number still.

What an alteration is brought about in the condition of the seed by the coming of the spring! With the increasing powers of the sun the cold earth becomes warmer every day, and this rise in temperature is the signal for which the seeds have been waiting. The gentle showers of spring water the earth, and the moisture soaking inwards through the husks of the seeds stirs the living matter to activity. As we shall see elsewhere, the store of food materials is at this time converted into a form available for the immediate use of

the little plant-to-be. It is interesting to see how cautiously the plantlet puts in an appearance at first. The small stem arches its way through the ground, and the tender leaves hang down, until they are more developed. During the spring weather, which is usually of a fickle character, we may feel certain that the drooping, huddled bearing of the seedling's initial leaves affords a real protection against cold.

In defiance of weather conditions a few plants have elected to come to perfection right in the middle of the winter season. Of these the Christmas Rose (*Helleborus niger*) is perhaps one of the most striking examples. It is interesting to see the manner in which the flowers of this plant are protected, so that they may not suffer from the cold rains of December. The bud of the blossom is of a pendulous habit, and even when the flower is fully expanded the essential organs are perfectly sheltered by the encircling sepals. In passing, it may be mentioned that the petals of the Christmas Rose are contracted into small tubular bodies, hardly exceeding the stamens in size. The flowers of the Hellebore seem to be able to hold over their own development for almost any length of time without injury until a fairly favourable spell of weather arrives.

CHRISTMAS ROSE IN WINTER.

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The earliest arrivals of the springtime will often have to face long turns of bad weather. That typical flower of the new year, the Snowdrop, is well adapted to meet almost any conditions. Owing to its drooping habit the close-fitting petals form a most perfect little roof to protect the delicate essential organs. A few weeks later, when the Crocuses put in an appearance, there will be more sunshine, but the weather is still in an uncertain state. Note the white protecting sheath which encloses the whole shoot until warmer conditions make it safe for the leaves and flower-buds to venture out. When quite open the Crocus blooms face right up to the sky, and are exceptionally exposed, but it is only in direct response to the solar rays that the flower will display its shining corolla. On dull threatening days the floral envelope is tightly closed, so that there is no possibility of any harm coming to the golden anthers. In much the same way the golden-yellow Coltsfoot, one of the earliest of our wild flowers, is so sensitive that it never by any chance opens unless the day is bright and warm.

III

THE PLANT AS A HOST

APART from the food and shelter provided by vegetation to animal life, one is not perhaps accustomed to think of the plant in its character as a host. Yet the question of entertaining guests enters largely into the existence of many species, and is a much more important matter than might at first be supposed. In considering the relations of the flower and the living agents which carry the pollen, we shall see how well the plant is able to reward those willing to render the required aid, but in the present chapter it is proposed to consider some far more intimate alliances. In some cases it is possible to show that the connections are of direct benefit to both the parties concerned—the plant providing housing, and even food, in return for services rendered. Other instances are more puzzling, in that although the plant does not appear to derive any advantages from its guests, yet it is willing to tolerate

their presence, and even to make some provision for their welfare. Finally, we find the plant as an unwilling host, with exacting visitors quartered upon it whose demands may be pushed to such an extent that its very life is at stake.

It has for long been realised that the relations between the plant and the ant present some remarkable points. The frequency with which these active insects are to be found in flowers cannot fail to have attracted the attention of observers. Now, in a certain way, the worker ants are not in the flower for any good purpose, having come to feast on the pollen and nectar. As these insects do not possess wings, they are not helpful in carrying the pollen from one plant to another, as bees and flies often do. Yet we cannot ignore the fact that in many cases the presence of ants in flowers is tolerated, if indeed it is not actually encouraged. As is well known, ants are peculiarly intolerant of the presence of other insects, and there seems no question that on occasion they will render ill-protected flowers a service in eating up other small marauders which come to plunder. It has been said, although the statement lacks confirmation, that ants will sometimes frighten bees away from flowers by the attacks which they make upon them. If this be

so, the guests are certainly exceeding their duties in driving away the helpful bees.

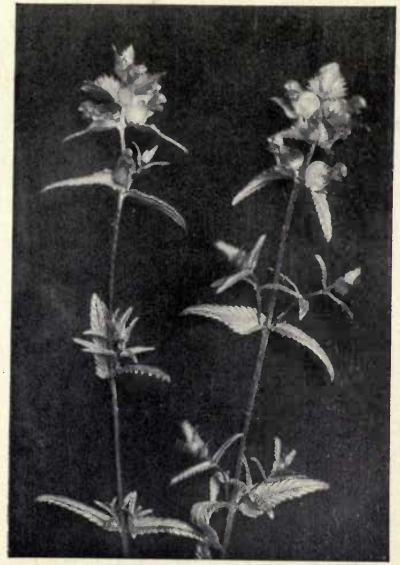
Certain plants are seen to develop nectaries in other parts than the flowers. In the common Laurel these occur at the bases of the leaves on the under side. The Cherry, as well as other allied species, produces nectaries in the form of small glandular swellings on the leaf-stalks. In addition, it is found that the Broad Bean bears nectaries on its stipules. The actual purpose served by these processes has long been the subject of a great deal of speculation. Some have held that they must be regarded as curious protective devices. It is argued that creeping insects bent on plundering the store of good things to be found in the flower are turned aside from their nefarious purpose when they discover the glands secreting nectar. Here is a supply of honey easily secured, so why should the little creatures trouble to go on to the blossom at all? In the case of the Scabrous Balsam, Kerner has observed that the drops of honey provided at the base of every leaf undoubtedly prevent a large number of wingless creatures from getting to the pollen. But it seems that the matter may be pushed to a still more interesting conclusion. These extra-floral nectaries will, of course, attract large num-

bers of ants, and the vigorous little creatures will certainly not allow any other visitors. Thus numbers of small beetles and other insects which happen to be trespassing on the plant are dealt with very effectually.

The relations of plants and ants are known to be more definitely intimate than in any of the foregoing instances. As long ago as 1688 the old naturalist John Ray observed the frequent occurrence of ants in the hollow stems of *Cecropia palmata* and some other South American plants. It was not until the latter part of last century that an understanding of the matter was in any way complete. The actual observations were made in the case of the Bull's Horn Acacia. In this tree it was found that the hollow thorns were inhabited by ants, the insects making a hole for their entrance and exit near one of the thorns. In these little homes they rear their young, and Belt declared that in the wet season every one of the thorns in the trees he examined (in Nicaragua) was inhabited. If any browsing animal should attack the tree, the ants resent the interference with great fury, rushing out to deal with the aggressor with jaws and stings.

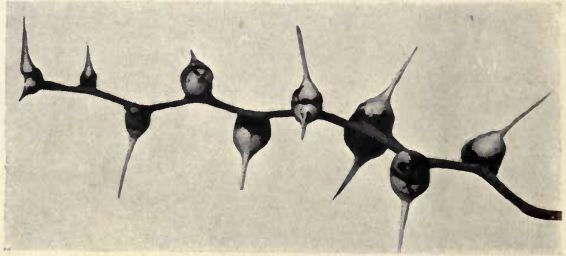
The services rendered to the Acacia go even beyond this. South American forest trees are much

subject to the onslaughts of leaf-cutting ants, whole armies of which will, at times, render a district almost denuded of foliage in a short while. The Acacias, which have enlisted the sympathies of the thorn-dwelling ants, are perfectly secure from attack. When the leaf-cutting species arrives on the scene it is to find the situation already occupied by hordes of ants fired by the enthusiasm which the defence of a home will always inspire. It is interesting to note the manner in which the ants are encouraged to take up their residence in the thorns. These when young are quite soft, and have their interiors filled with sweet edible pulp. As the insect eats away the contents of that which is to be its home, the thorn swells at the base and thus becomes more commodious. As well, at the bottom of each leaflet there is produced a small sweet gland, and in addition a tiny yellow food body at the end of each division of the leaf. So that it will be seen that the tree makes handsome provision for its army of defenders. It is only during the wet season that such liberal arrangements are made for the welfare of the ants. As soon as the time for the sending out of young shoots is past the honey glands dry up, and, left without their food supply, the majority of the ants perish. A sufficient



YELLOW RATTLE, A PLANT WHICH IS PARTLY PARASITIC ON GRASS ROOTS.

LAUREL LEAVES SHOWING NECTARIES.



AN ACACIA WITH SWELLINGS AT THE BASE OF THE THORNS, WHICH ARE INHABITED BY ANTS.

number, however, survive to carry on the race during the time of scarceness.

Recent investigation has shown that the story of this strange compact between the ant and the Acacia trees is not at all exaggerated. The same state of affairs has been observed in quite a number of trees. In the case of the hollow-stemmed Cecropias, it has been found that the specimens which had suffered from the attacks of leaf-cutting ants were for some reason or other without their bodyguard. With the Cecropias the ants enter the stems by means of a little door which they always make at one spot on the stem where the tissue is very thin. Here also the plants are provided with a plenteous supply of food. Near the base of the leaf-stalks are to be found brown patches on which are collections of oval bodies. These are highly nutritious, and are eaten greedily by the ants. It is certainly significant that, both in the case of the Cecropias and the Acacias, the food bodies are absent where the particular species is not inhabited by ants.

It must not be supposed that in all cases where ants and other small creatures are found to be associated with plants it is possible to make out a clear case of mutual help. The curious plant *Myrmecodia tuberosa*, from the Malay Archi-

pelago, is a case in point. The species is altogether most singular in appearance, and consists of a tuberous growth spreading on the branches of old trees, from the upper part of which spring the fleshy stems bearing the foliage. Every part of the tuber is tenanted by small red ants of a very fierce habit, which rush out and defend their homes when any attack is made. Some years ago, certain observers declared that it was through the agency of the ants that the tuberous growth was formed. The story was seriously placed on record that the bites of the ants caused the basal swelling, and also the formation of galleries in which the insects subsequently took up their abode; failing these attentions, it was declared that the vegetable invariably died. This has of recent years been entirely disproved, for it has been shown that specimens of *Myrmecodia* may be easily raised from seed and grown to a perfect development, even if ants are entirely excluded.

The Yucca plants are natives of America, and when the specimens are in flower a little moth, known as *Pronuba yuccasella*, may be seen flying round the blossoms. The females of the species spend most of their time in the blooms, where they make arrangements for a novel form of egg-laying. The moth starts with the rolling together

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THE YUCCA.

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of a ball of pollen. As soon as this is ready, it is carried off to another flower, where the insect lays an egg at the base of the pistil, by thrusting its ovipositor down through the soft tissue. This done, the moth mounts to the summit of the style and places the ball of pollen upon the stigmatic surface, thereby ensuring the fertilisation of the ovules. When the caterpillar hatches, it finds itself supplied with food material in the surrounding tissues; there the larva will remain until the ripening of the seed, when it eats its way out, crawls to the ground, and then turns to a chrysalis under the surface. It is believed that the Yucca never sets seed unless it has received the attention of the little moth. In return the grub of the insect is provided with food and protection. The ravages of the little guest do not materially affect the seed production, seeing that the number of ovules is considerable.

As a general rule, the numerous galls which are found so abundantly on the Oak, and also on certain other trees and plants, cannot be said to be harmful to the vegetable. Now and again, when the insects producing them become very abundant, growth may be stunted by the presence of the galls; or, as in the case of the dreaded grape louse of Southern Europe (*Phylloxera*), the

plant perishes under the attacks which the minute creatures make upon it. Mostly, however, the plants seem to be neither better nor worse for having to develop the little houses in which the insects find a residence. Everyone must be familiar with the large round "gall nuts" which are found on the twigs of the Oak. Whilst these are, of course, produced by the plant, the underlying cause of growth consists in the irritation set up by the minute gall wasps when the insects lay their eggs in the buds. These particular galls are but types of an immense number of examples exhibiting a wide range of form and size. Moreover, the life histories of the insects with which they are associated are in many cases imperfectly understood.

A very singular case of partnership between plants is that which is seen in the case of the Lichens. These used to be regarded as distinct individuals, capable of definite classification on the lines of other plants. It has been established that this is entirely a mistaken impression. Researches have shown that the Lichen is not a separate plant at all in the ordinary sense of the word. Rather must it be regarded as a case of that which has been called "symbiosis"—literally, the living together of two very distinct

organisms. Every growth of Lichen must be thought of as a colony composed of thousands of individuals, in which, however, there is always one predominant. The chief partner of this strange alliance is a fungus, which encloses in its embrace a countless number of green Algæ.

In a certain sense it may be said that the fungus is parasitic upon these minute organisms, but only to the extent of stimulating the Algæ to great activity and vigorous increase. Both partners to the alliance appear to receive benefits from thus living together. Although at first this startling theory aroused an immense amount of opposition, there is no longer any doubt as to its correctness. The most convincing proof was that advanced by Stahl, who after some patient experiments at last succeeded in making Lichens by artificial methods. He took a well-known species of Algæ, and on this scattered the spores of a fungus. The result of this union was a Lichen in the form of a well-recognised growth. Again, it is possible to take any of the so-called species of Lichen, and start the constituents of the double organism on a separate existence. It is then seen that the little cells of the Algæ flourish and multiply, whilst the fungoid element of the union as surely starves. Now and again it is

found that a lichenous growth of one type may embrace several distinct species of Algæ—familiar examples which are well known apart from this strange alliance.

A little-understood union is that to be seen in the case of Beeches, Birches, and some other trees. Here it is seen that the root tips are infested with a network of fungus threads. It has been suggested, although not actually proved, that the threads act as a kind of sponge between the roots and the soil, possibly taking some part in the transmission of moisture. In some instances it is known that the fungus threads really penetrate the substance of the roots, but it does not appear that any harm results.

In the tropical forests the branches of the trees offer resting-places for a host of plants. These species are entirely isolated from the ground, and were at one time regarded as parasitic in habit, but such is not the case. They lead quite independent existences, carrying out the elaboration of their chlorophyll in the ordinary way. For their moisture and mineral matters these perched plants rely upon rain and the atmospheric dampness which is such a feature of the steamy jungles. It is interesting to note that the roots of most epiphytes are specially adapted

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"SPANIARD'S BEARD."

for absorbing moisture from the air, the skin being of a peculiarly spongy nature. There is little doubt that in many cases the debris, composed of rotting leaves, which collects in the forks of the branches, forms a good rooting medium.

A large group of plants in tropical America is formed by the many species of Tillandsia. One of the most curious of these, known as "Spaniard's Beard" (*T. usneoides*), offers an example of a conspicuous and widely distributed epiphyte. This species has no real roots, but drapes itself round the branches of its host by means of its long thread-like stems of a silver-grey colour. A good proof that the Tillandsias are not in the least dependent upon soil is to be seen in the case of one of the species at Kew. This example, which comes from Trinidad, has been suspended from the roof of a greenhouse for a long time. The roots of the specimen are simply in the warm, damp atmosphere of the hot-house, yet the plant thrives perfectly well. The great Aroids of the genus Philodendron, and the strange Monsteras, perch high in the branches of trees, whence they send down long aerial roots. Although a great deal of moisture is absorbed from the air by these processes, they not infrequently find a final resting-

place in the damp soil beneath. As is well known, a large number of tropical Orchids are epiphytical in habit, and by their gay flowers adorn the branches of the forest trees with loveliness.

The plant is called upon to provide accommodation for many of its own kind, but it is to be feared that in a large number of cases the guest is not a welcome visitor. Quite often the host does not suffer greatly from the attentions which are pressed upon it. The mildly parasitic Mistletoe does not appear to be a great drain on the resources of the trees upon which it grows. The plant selects a wide range of hosts, embracing nearly all kinds of the common deciduous trees. In Britain, at any rate, the Mistletoe is chiefly found on the Black Poplar. The manner in which the parasite is distributed is very interesting. In winter the white berries are largely eaten by birds, and a certain number of the seeds will be likely to adhere to their beaks. To get rid of the encumbrance, the bird cleans his bill by rubbing it backwards and forwards on the bark of a branch. In this way the seed is placed in the best possible position for its purpose. As the seed germinates, roots are sent down into the tissue of the branch on which it rests, and the Mistletoe becomes quickly established. We may see from the leaves

of the plant that it is not a very depraved parasite, the pale green foliage indicating that the elaboration of chlorophyll is carried on to a certain extent.

The story of the Dodder, a parasite of the most abandoned description, is a very different one from that of the Mistletoe. These remarkable plants, of which there are several species found in Great Britain, have given up all attempts to make a living for themselves in the proper manner, and have appeared on the scene as undisguised robbers. The life history of a typical species, *Cuscuta epithymum*, is most curious. The seed of the plant germinates in the soil in the usual manner of most plants. One fact which is significant is that, unlike most other flowering plants, the embryo of the Dodder is not provided with any reserve of food material. What little nourishment the developing plant requires, until it can enter upon its parasitical career, is drawn from the albuminous matter within itself. Soon after germination the thin radicle pushes its way down into the soil; meanwhile a red filament spreads upwards. It is a matter of urgency that the young Dodder should at the earliest possible moment be able to find a host, unless it is to perish miserably. The red shoot elongates at a

considerable rate, and finally comes into contact with a suitable plant.

The particular species under consideration is very partial to furze and heather. At once the character of the plant is revealed; the root dries up, the harmless-looking threads produce suckers at the points of contact, and entwine themselves round the stems of the unfortunate plant selected as a victim. From thenceforward the red shoots of the Dodder increase at an incredible rate, thrusting out in all directions, and, wherever possible, affixing the suckers which drain away the life from the miserable host. About July, the Dodder develops its clusters of small white flowers, and soon afterwards the red filaments decrease in the vigour of their growth, and the parasite finally disappears. Quite often the plant which has been attacked is so miserably weakened that it perishes before the Dodder; but the activities of the parasite are such that it quickly transfers its operations to any adjoining specimen which may be suitable for its purpose. As showing what a formidable enemy the Dodder may be to the plant, even the hardy furze bushes not infrequently fall victims to the onslaughts of the parasite.

Of root parasites there are two very distinct

THE DODDER (*CUSCUTA EPITHYMUM*) ON HEATHER, A COMMON BRITISH PARASITE.

groups—those which are only partially dependent upon their hosts, and those which can in no way support a separate existence. The common woodland plant, the Cow Wheat (*Melampyrum*), attaches itself by disks to the surrounding roots of its neighbours, yet this union only occurs in the case of a proportion of the roots. The plant has, too, independent soil roots, and at the same time develops perfectly green leaves. In much the same way the Yellow Rattle (*Rhinanthus*) of our pastures attaches some of its roots to the underground runners of grass. Yet so green is the foliage, and so abundant the independent roots, that the plant can only draw to a small extent upon the resources of its host. These two species are only types of several hundred plants, existing in various parts of the world, which live partly at the expense of their hosts by means of root attachment.

There are few more curious plants than the Toothwort (*Lathræa*), a species which is wholly given over to parasitism. Owing to the courtesy of Mr. E. J. Allard, of Cambridge, the writer is able to give an illustration of the Toothwort. Though not common the plant has a wide distribution, being found on the roots of Poplar, Hazel, and other trees. The Toothwort is very

easy to establish, and it may be seen growing in great abundance in several botanic gardens. The appearance of the plant is very singular, with its thick spikes of pale lilac-tinted flowers. Below the surface of the soil it is possible to see the manner in which the Toothwort gets a living. From the roots of the plant arise suckers—in one species (*L. clandestina*) as large as split peas—by means of which the roots of trees are penetrated. Another plant of similar habit to the Toothwort is the Broomrape (*Orobanche*), which grows as a parasite on the roots of many common plants, notably Broom and other leguminous species. The Broomrape has, of course, no true leaves, and looks more like a withered flower-spike, so dingy is the colouring of its inflorescence. There are several species of *Orobanche* to be found in Britain, one of which (*O. major*) is quite frequently to be met with. It does not seem that these root parasites are actually very harmful to the plants upon which they force their attentions.

One could not very well leave the subject of plant parasites without a reference to that wonder of the world, the *Rafflesia Arnoldi*. This species, which was discovered in Sumatra in 1818 by Dr. Arnold, is so curiously modified that it is almost reduced to one giant flower. The blossoms are

LATHRÆA SQUAMARIA (THE TOOTHWORT).
A species which is parasitic on Hazel roots.

of colossal proportions, measuring as much as three or four feet in diameter. The Rafflesia usually attaches itself to the roots of the trees which are close to the trunk, and presents a most striking appearance. The colouring of the enormous petals is of a lurid reddish brown shade, and the flower is said to attract large numbers of winged insects. The Rafflesia is typical of a large number of parasitic plants found in tropical countries, which attach themselves to the roots of trees and live on the sap of the host plant.

IV

THE PLANT AS A PARENT

THE first duty of the individual, and one even more important than the preservation of its own life, is the perpetuation of the race. It is easy to think of the care which the animal bestows on its offspring, the food and protection which the parent provides, the fostering of the new generation for its advent into a world of strife. We are not so prone to regard the plant as a parent, responsible for the reproduction and outfitting of its kind. Yet the members of the vegetable kingdom take many extraordinary precautions to ensure the well-being of their progeny, and the study of these forms a very fascinating chapter in the book of Nature.

In the present instance it is not proposed to enter into the wonders of the floral marriage, but to presume that the ovary has received the touch necessary for its development, and that the seed is an accomplished fact. Now a seed has never,

perhaps, been better described than as "a tiny plant wrapped up in a packet of food material." Cutting through the protecting skin of a bean, it is found that the seed easily splits up into two pieces. Between these two cotyledons, as they are called, we shall find the germ—a perfect little plant in which all the parts are plainly discernible, though on a diminutive scale. In the case of the Bean, in common with many dicotyledonous plants, the supply of starch for the use of the young plant is absorbed into the cotyledons. The very large number of seeds possessed of only one cotyledon carry the supply of food material in a separate store, which is spoken of as the albumen. The substance set aside for the nourishment of the seedling is sufficient to give the plant a good start until it is able to set up housekeeping on its own account.

The seed has been endowed with a marvellous vitality. If the conditions are not suitable for its development it can very well wait until the circumstances are more favourable. Thus, it is seen that the seeds which fall to the ground in the autumn do not, as a rule, germinate until the following spring or summer. Well authenticated instances are on record where seeds buried deeply in soil have remained in a state of suspended

activity for many years. Finally, when digging operations have brought them more near the surface, they have readily germinated, apparently little the worse for their long confinement.

Granted certain conditions, the seed will speedily show signs of development. Warmth, moisture, and the presence of oxygen soon stir the sleeping embryo into life, and bring about the wonderful changes connected with the birth of the plant. Heat is necessary for the forwarding of all vital processes; moisture is required for the conversion of the nutrient into a fluid state, whilst oxygen is necessary in order to bring about the change of the starch into sugar, in which form it can be assimilated by the plant. In a chemical sense, starch and sugar are not widely different, save that the former contains an additional proportion of carbon. The absorption of oxygen by the seed sets free some of the carbon, and thus changes the composition of the food supply. At first sight it may seem strange that in the beginning sugar was not stored away in the seed. It is a wise provision that has ordered it otherwise, for had sugar been deposited in the first instance it would almost certainly have undergone fermentation. In this condition it would, of course, have been useless for the nourishment of the little plant.

The most obvious change in the appearance of the seed when conditions favourable for its germination are present, is a decided increase in size. This goes on apace until the outer skin bursts, and two very distinct parts are to be seen. One, whitish in colour and sometimes branched, sinks at once into the soil—this is the root ; the other, of a light green shade, rises above the ground—this is the shoot. In the germination of the seed we are witnessing a phenomenon which has provided the puzzle of the ages. What is it that induces the radicle with such persistence to plunge into the soil ? However the seed may have been placed when it germinated, the root always wriggles round so as to strike straight downward. Seeds which have been continually turned go through the strangest contortions in order that they may anchor themselves in the ground. It might be thought that it was the desire of the roots to get away from the light, had it not been shown that seeds grown in a box with holes in the bottom will send their radicles down through the openings out into the open. In doing so they leave not only the darkness behind them, but also the moisture in which they germinated.

It has been suggested, and with a good deal of reason, that the law of gravitation has not a

little to do with this strange tendency on the part of plants. Years ago a president of the Royal Horticultural Society, Mr. J. A. Knight, germinated Bean seeds on the rim of a vertical wheel, which was always kept revolving. Arrangements were also made to keep the seeds in a moist condition favourable to growth. It was found that the roots of the seedlings now grew outwards away from the centre of the wheel. From this it would appear that when the action of gravitation was overthrown by the centrifugal force of the revolving wheel the little plants were influenced by the new power. Thus it seems to be evident that the influence of gravitation in directing the course of the roots of seedlings is considerable. This does not by any means offer a complete solution of the problem; for whilst the root goes downwards the shoot with almost equal precision directs its growth upwards. It must be admitted that there is something more than a mere mechanical influence at work. We are indeed brought face to face with one of those mysteries which are as inscrutable as life itself. The most that can be said is that the radicle of the seedling is endowed with a geotropic tendency which impels it to bury itself in the earth, the tendency of the shoot meanwhile being in an

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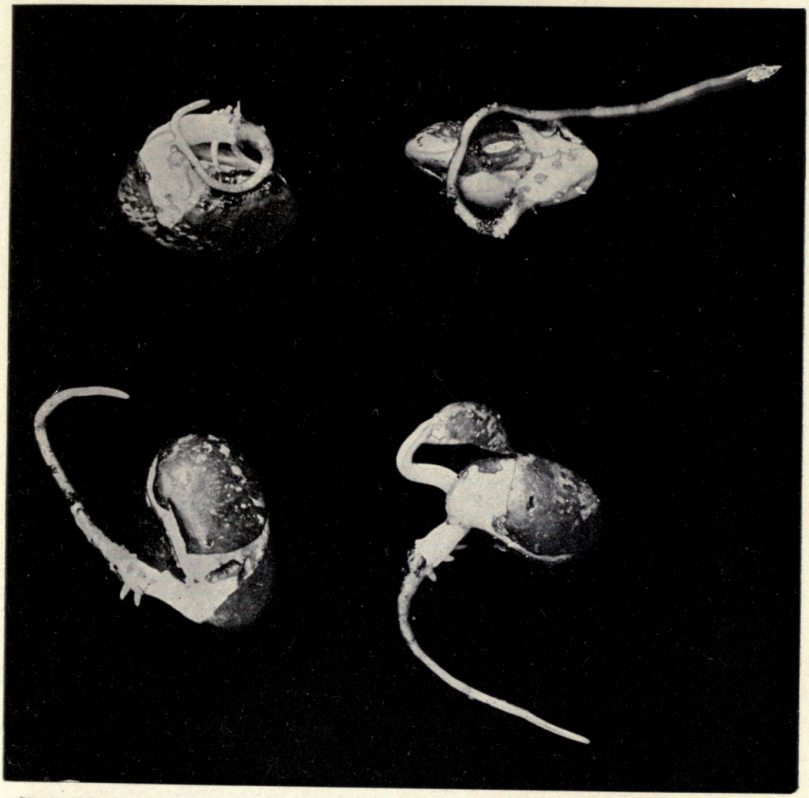


THE RADICLE OF THE BEAN WILL TWIST IN A STRANGE MANNER WHEN THE SEED IS TURNED DURING GROWTH.

opposite direction. As to the underlying causes of the happenings we are in complete ignorance.

Whilst the radicle of the seedling must always grow downwards, such is not the case with the secondary roots. These spread out laterally, and, indeed, can be induced to develop in an entirely opposite direction to that taken by the initial root. Thus, even if the radicle of the plant is injured in such a way that it cannot develop, the branch roots speedily come to the rescue. The seedling has indeed been endowed by Nature with extraordinary energy, and frail a thing as the little plant appears to be, it is not easily killed. Even if the plumule happens to be broken off altogether, this is speedily replaced by a fresh shoot, and the plant emerges on the scene but little the worse for the accident.

Throughout its life history the average plant is chained to one spot. It flowers, perhaps produces its seeds, without difficulty, and yet there still remains a problem which is by no means easy of solution. In certain circumstances the parent plant may be the greatest enemy of its own kind. The very fact of its continued existence after fruiting may form a serious menace to the well-being of its offspring. The seeds which fall on to the ground surrounding a perennial come

up to find a well-established plant already in possession of the field—when their chance of arriving at maturity is exceedingly remote. There is no room for apprehension of this kind on behalf of annual plants, and it is curious that, generally speaking, the provisions for wide seed distribution of these species are not so pronounced as in the case of perennials. It is a very different matter with plants which live for more than a year, and many ingenious devices have been brought into being to ensure the scattering of the offspring over a wide area.

Some of the most beautiful arrangements to secure the passage of the seed are evinced in those which are designed to be carried hither and thither by the wind. A vast number of seeds produced by the composite plants are contained in vessels provided with appendages to enable the processes to float away on the breezes. These devices reach their perfection in the various members of the Thistle family, which surround their seeds with the most perfect flying apparatus imaginable. Anyone who has watched a clump of Thistles on a breezy autumn day must have marvelled that the whole world has not long since been crowded out by these aggressive weeds. Every puff of wind raises the downy seeds from

THE DANDELION IS TYPICAL OF THE FLYING SEEDS.

THE SEEDS OF THE BULRUSH ARE CARRIED TO GREAT DISTANCES BY THE WIND.

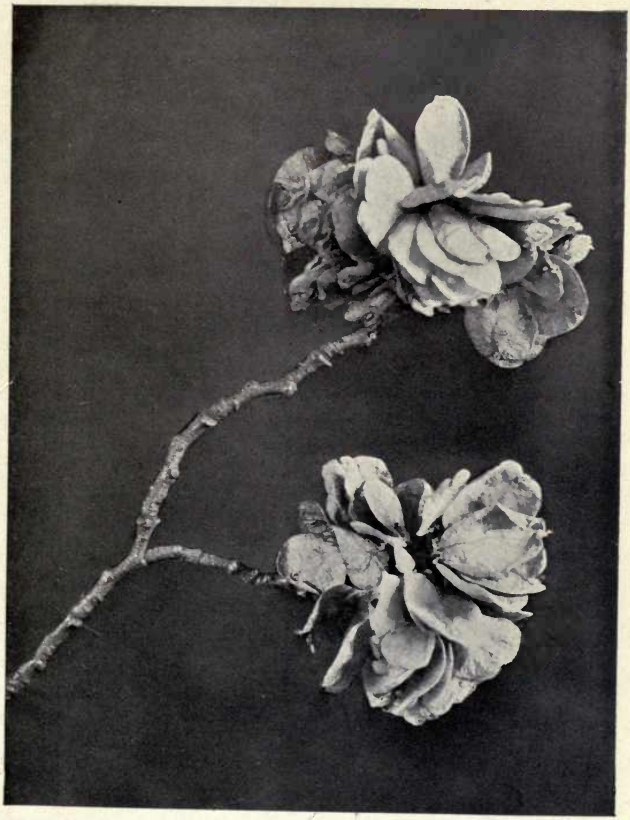
the plants, and away they go scudding over the country until they settle in some situation from which they cannot escape. The seed vessels of the Thistle often rise to a height of thirty feet in the air, and when at this elevation it is not unreasonable to suppose that they travel a mile or more before finally settling down.

Following after the Thistle there is a whole host of plants producing seed vessels which have tufts or crowns of hair as attachments. The pretty little parachute-like device of the Dandelion seed, the hairy tufts of the Willow Herb and Bulrush vessels, all materially assist in the dispersal of the plant's progeny over a wide area. A little plant, common enough in some meadows, known as *Thrincia hirta,* produces two kinds of seeds; one is provided with hairy appendages, the other is not. The former are specially adapted for travelling over a considerable distance, whilst the latter are for the perpetuation of the species nearer home.

The seeds of many trees, although they cannot rival the length of flight accomplished by the Thistle, are by means of their formation wafted to a considerable distance. If the fruit of an Elm be examined a curious wing-like expansion is found, which when a moderate breeze is blowing

enables the heavy seed to float away from its parent. In common with those of the Maple, the Sycamore seed vessels go round and round, and thus retard the rapidity of their fall to the ground. The golden long-stemmed blossoms of the Lime are developed with a green bract, and this appendage remains until the late summer. When the ripening of the seed has come about the whole process is detached from the tree, and as soon as it is in the air the use of the bract becomes apparent. The seed capsules are heavy, and pull the device into an upright position, in which state, as it falls, it commences to revolve with amazing rapidity. This induces a very leisurely fall, and, of course, all the while the process is sinking it is being carried farther afield by the breeze. The small seeds of the Birch are surrounded by a membranous expansion which, as the vessels leave the tree, catches the wind and away they sail—not to settle down, perhaps, until they are some hundreds of yards away from the starting point.

Not a few plants rely upon water as the means by which their seeds are distributed. The strange double Coco-nut, the fruit of a Coco Palm, was a tremendous puzzle to early navigators, who very often found specimens floating in the sea many



THE SEED OF THE ELM IS SURROUNDED BY A WING-LIKE EXPANSION.

miles from the nearest land. The question was not definitely settled until the discovery of the Seychelle Islands, when the palm bearing the nuts was identified, thereby clearing up a great mystery. It is by ocean currents that the common Coco-nut has been distributed so widely among the Pacific islands. Almost the first tokens of vegetation on the coral reefs are the Palm trees, which appear on the smallest patch above high-water mark. The preparation of the Coco-nut for its long sea-voyage is a matter to which the plant has given special attention. In the first place the embryo and supply of food material are encased in a singularly dense shell, but outside of this is an enormous fibrous mass completely enveloping the nut itself. The distance over which these seeds will float is extraordinary, and were it not for the limited climatic range the species could not fail to have been established all over the world long ago. It is a well-known fact that seeds of various plants indigenous to the West Indies are not infrequently found on the north-west coast of Norway, where they have been swept round by a branch of the Gulf Stream.

In Britain the movements of water-borne seeds are to be observed in the case of many plants which grow on the banks of rivers or streams. The

charming Snowflake, a plant which is probably not a native, spreads amazingly by means of its seeds; these are encased in a capsule which readily floats. On the Loddon, a tributary of the Thames, the species has spread up and down the stream amazingly, and it is gradually extending to the main river. As years go by it is likely that the Snowflake will become increasingly plentiful, until it is distributed throughout the Thames water-system. An astonishing illustration of the distribution of a plant by water is that afforded by the American water-weed *Elodea Canadensis*, a species which somehow was introduced into Britain about sixty years ago. In this short while it has managed to spread over most of the water-ways of Great Britain. Indeed, in many districts the plant has blocked canals to such an extent that it has proved a real hindrance to navigation.

The number of seeds which are distributed by animal agency is immense. All kinds of devices are adopted to secure the conveyance of the seed from its parent to a distant situation where it will stand a reasonable chance of securing room for development. Those seeds having hooked vessels exhibit a variety of method which is amazing. Some, like the Martynias of America, are provided with hooks many inches in length;

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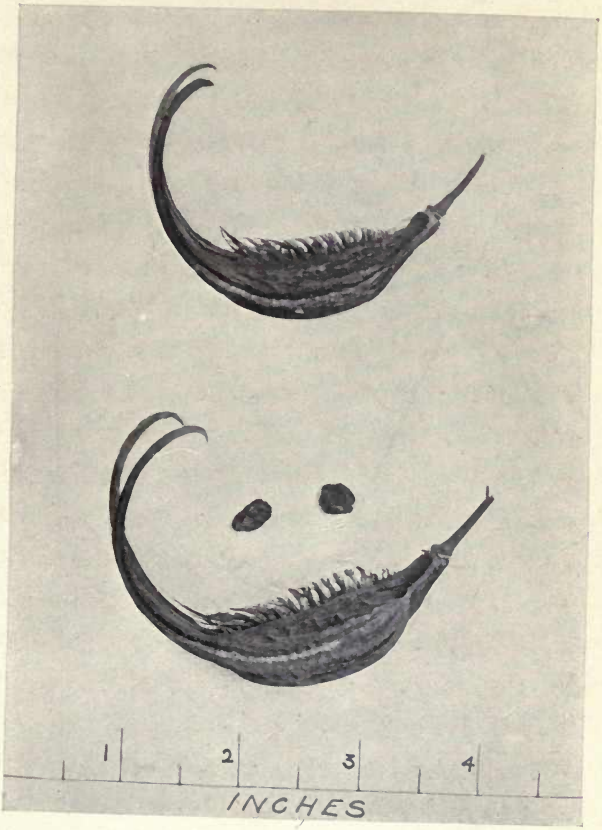

THE SEED CASES OF THE MARTYNIA.

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these seize hold of any passing animal as it plunges through the forest, becoming deeply embedded in the flesh, and the victim will perhaps travel several miles before it can divest itself of its painful burden. Even more formidable still is the seed vessel of the South African Grapple Plant (*Harpagophyton procumbens*). These roll about over the dry plains, and as they are provided with a large number of curved hooks, readily attach themselves to the coats of animals. Indeed, it is said that they have even been known to cause the death of lions. Finding some of the seeds attached to its skin, the animal endeavours to tear the cruel hooks away, with the result that it gets one of the vessels hopelessly entangled in its mouth, and so perishes in a most miserable fashion.

Many of our British plants produce seeds provided with hooks, although these are nothing like as formidable as the two foreign species described above. Indeed, the seed vessels of the Agrimony, the Cleavers, and the Burdock are really objects of great beauty. That the processes serve their purpose admirably is well known to anybody who has taken a walk in a field at seeding time. One's garments become quite thickly covered with the seeds, which hold on with great

tenacity. From this it is easy to get an idea of the distance to which many of these may be carried whilst clinging to the coat of some wild creature.

A very large number of plants are able to surround their seeds with a pulp which is attractively flavoured. It is certainly a curious fact that just at the time when the seeds are ready for dispersal the fruit or berry becomes a bright colour, as if the plant were anxious to attract attention to its progeny. In many of these cases the seed is protected by a hard covering that is quite unaffected by the digestive juices of any animal which should happen to swallow it when feasting on the fruit. It is not always that the seeds of fruits and berries are swallowed by the bird or animal acting as the distributing agent. It has been noticed elsewhere that the seeds of the Mistletoe are frequently carried about on the beaks of thrushes. Many of the seeds, such as chestnuts, Beech-masts, acorns, which are edible in themselves, are destroyed in large numbers by the animal life of the country. On the other hand, owing to their value as food, a large proportion of them will be carried to considerable distances by squirrels and other creatures, and perhaps dropped, or stored away and forgotten

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POPPIES.

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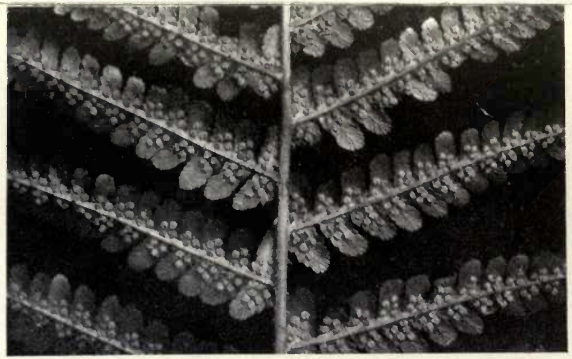
altogether. In a slightly different way enormous numbers of seeds which are eaten by birds rely for their dispersal on the fact that whilst feasting the winged creatures will almost certainly pick up a few on their feet. In this manner they will, of course, be carried to great distances.

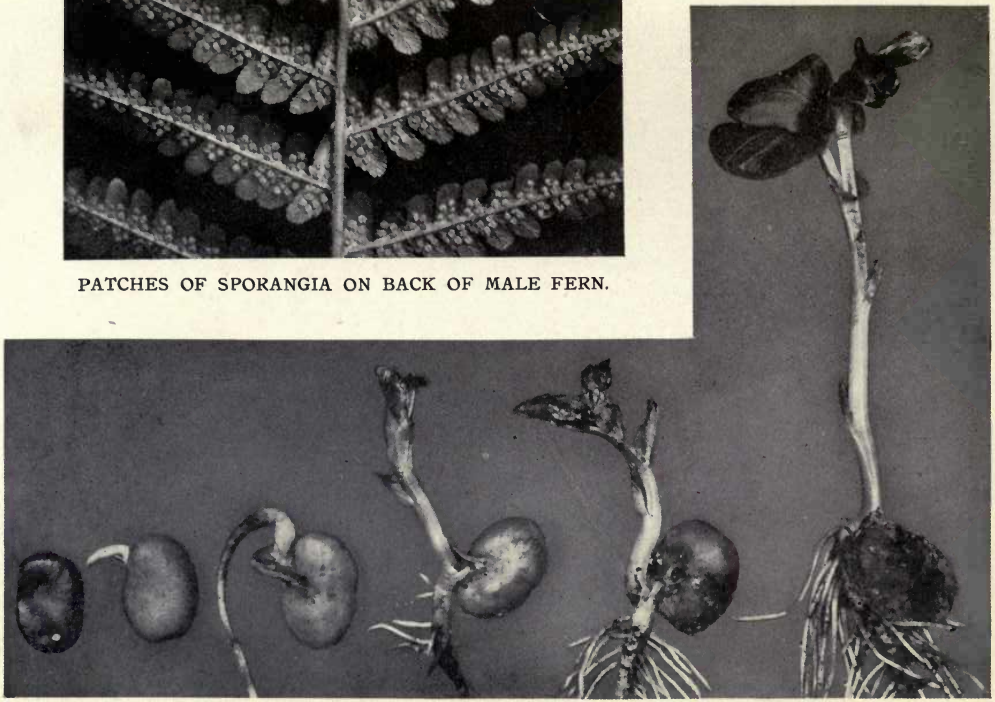
A very interesting group of plants are those which, by sheer force, expel their seeds from the cases. One of the most curious examples in the world is certainly the Sand Box tree, the seed case of which, as it dries, becomes in a state of considerable tension. At a certain stage of its development the large capsule bursts, hurling the hard seeds with great force in all directions. It is said that passers-by have not infrequently been injured by the flying seeds. In much the same way the Para Rubber tree scatters its seeds afar, and when these are ripening in a plantation the sound resembles the constant firing of pistols. To come to more homely instances, the common Balsams of our gardens possess seed vessels which are veritable popguns. When the seeds are ripe for ejectment the five divisions of the capsule burst open and throw out the contents with a good deal of violence. The pretty little English Wood Sorrel offers another example of those plants which scatter their seeds with force. As soon as

the seeds are ready for dispersion the capsule splits open, and the strong tense tissue covering the seeds thus suddenly ruptured, throws them to a considerable distance.

Not a few of the pod-bearing plants contrive to have their seeds scattered afar by means of their legumes, which, when dry, curl up in spiral fashion and so eject their contents. A very simple device is that adopted by the Poppy, in which the capsules scatter the seeds as they are blown backwards and forwards by the wind. Even with this arrangement the distribution covers a much wider area than might be thought possible. A strange form of seed dispersion is that to be seen in the case of the Earth Nut (*Arachis hypogæa*). The singular part about this plant is that, as the seeds begin to ripen, the pods are forced below the surface of the soil through the lengthening of the flower stalks, and are in this way actually planted. The same method has been adopted by the Sweet Violet, and also in the case of a few other plants. The phenomenon is certainly rather a puzzling one, for the behaviour of these species can scarcely be said to aid in the wide dispersal of the plant. In some of the instances which possess this strange habit, there are, in addition to the subterranean pods,



PATCHES OF SPORANGIA ON BACK OF MALE FERN.



THE NORMAL DEVELOPMENT OF A BEAN.
The shoot goes up and the root goes down.

aerial ones which bear their seeds in a more ordinary manner. We may suppose that the seeds which are so carefully sown by the plant are put into position in order to make quite certain that the species shall continue to hold its own on that particular spot.

The large number of plants which do not produce flowers make comparatively little provision for the welfare of their offspring. The early observers were much puzzled as to how it was that Ferns which appeared never to produce seed were able to increase their kind. It was not until the coming of the microscope that the strange life history of the Fern was understood. An examination of the brown patches to be found on the back of many Fern fronds shows them to be groupings of strange little stalked cases, called sporangia. At a certain stage in their existence these sporangia burst open, and scatter their contents to the winds of heaven. This matter is formed of numbers of individual grains, in form varying largely in the different species. These spores are very different in their formation from the seeds of flowering species; each one is little more than a speck of life in an elementary form.

Although the process of development from the spore to the Fern plant varies considerably, a

typical case may be briefly outlined. Being very light, the spores float away on the slightest breezes and a certain number of them are sure to find a resting-place on some moist patch of soil. It is not very long after the lodgment of the spores that a change takes place, which by a process of cell extension results in the production of a heart-shaped green film in measurement about an eighth of an inch known as the prothallium. After an interval, two very distinct kinds of cells begin to put in an appearance upon the under-side of the prothallium. These represent respectively the archegonia, or germ cell, and the antheridia, or sperm cell. At a certain stage in the history of these cells, thread-like processes, known as antherozoids, emerge from the sperm cells and enter the germ cells, and thus bring about the fertilisation of the embryo. Soon after this has been accomplished the prothallium and all its system of cells dries up, leaving behind only the fecundated germ. Yet another change, and the tiny frond struggles upwards, and the birth of the Fern is an accomplished fact.

V

THE PLANT AND ITS HELPERS

In the fierce battle of life there is small chance for the exercise of charity. We have no evidence to show, apart from certain instinctive traits, that one being ever helps another unless something is given in return. The plant, owing to the many inherent disadvantages under which it exists, is sorely in need of helpers to enable it to carry out the functions which it is bound to perform. Yet, surrounded as it is on every side by enemies, it has not been an easy matter to enlist the services of those who are in a position to lend their aid. To this end some of the more ingenious devices in the vegetable kingdom have been brought into being, and there are few more interesting phases of plant life than the relations of the plant and its helpers.

Although the question is one concerning which there is a great diversity of opinion, it seems almost certain that plants benefit by the cross-

fertilisation of their blossoms. It is not easy to avoid the conclusion when one considers all the marvellous arrangements which have been entered into, presumably with this object in view. The fact, too, that in so many cases the male and female organs in the flower mature at different times suggests that self-fertilisation is not wanted. Not the least amazing feature is the variety of the agents which are induced to help the plant in the distribution of its pollen. Insects, spiders, birds—even the wind and water—act as emissaries in this marriage of the plant. The intricacies of some of the relationships are so astonishing that it must always be a matter for conjecture as to how such things could come about.

Overshadowing all else in connection with the cross-fertilisation of flowers is the work accomplished by insects. It will be no exaggeration to say that hundreds of thousands of species embracing nearly all classes are actively engaged in pollen transference, although it is likely that the insects are in total ignorance of the services which they render. It is evident that it is necessary for the plant to offer some inducement, so that it may appear to be worth the while of the unwitting helper to visit the flower. In most cases this attraction is to be found in the nectar which the

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ANTIRRHINUM.

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blossoms secrete, and this will act as a never-failing bait to draw the insects into making a call. The nectaries themselves present a variety of forms, sometimes appearing as sunk glands, on other occasions being grooved, whilst again they may resemble small warts. These processes are, as well, placed in different parts of the flower—in the Japanese Lily they exist as grooves on the perianth, whilst in the Buttercup we may find them at the base of the petals. Even the essential organs themselves are nectary bearers, as is to be seen in the case of the shortened stamens of the Cuckoo Flower, and the ovaries of the Antirrhinum and Veronica.

The showy flowers of the Grass of Parnassus are of special interest, from the fact that in the centre of each bloom an arrangement of hairs gives rise to a curious illusion. Each of these processes presents the appearance of being tipped with a shining drop of nectar, although the knobs are quite hard. Anyone who cares to watch the flowers of this charming bog plant on a fine summer day will see that a large number of flies are deceived into the belief that the glistening points will yield them some reward if they visit the flower. The little insects seem to be quite disgusted when they discover that the

feast of honey which they had expected to find does not exist at all. Yet the clever plant has achieved its object in drawing the attention of a visitor who will be likely to aid in the dispersal of the pollen.

It seems almost certain that in not a few cases the pollen itself is offered as an inducement to the insect to visit the flower. There is little doubt that large numbers of small beetles, which in one way may be regarded as robbers, act as the agents for the carrying of the pollen from one bloom to the other. This is easy to understand in the case of those plants which produce pollen largely in excess of their actual needs. An observer has been at pains to count the number of grains produced by the flower of the Hibiscus. It was estimated that sixty grains would be amply sufficient to fertilise all the ovules of the blossoms, whereas in a normal case the stamens were responsible for five thousand. Even this number is small compared with the quantity of pollen grains produced by the Dandelion, estimated at nearly four hundred thousand; whilst in the case of the Peony the number has been placed at between three and four millions!

There is no doubt that insects are often attracted to flowers by their appearance and scent.

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SOME SPECIES OF IRIS HAVE AN UNPLEASANT SMELL WHICH IS ATTRACTIVE TO CERTAIN INSECTS.

Many blossoms advertise their presence by the gay colours which they display and the sweet perfumes which they exhale. Almost all kinds of flies are very prone to settle on anything which is strikingly marked, and not a few plants have turned this tendency to account. The observations of many students of this particular phase of plant life have gone to show how gaily coloured flowers receive first attention. It has also been demonstrated that certain insects are attracted by a particular colour, and choose this in preference to others. Thus, from the experiments of Lord Avebury it appears that bees will, if there should be any choice in the matter, select the blue flowers, while flies seem to be more partial to those of a yellow or brown tint.

Many species with insignificant blooms have called to their aid showy bracts to advertise the presence of their flowers. Of these, the South American Poinsettia is one of the most striking examples. In this case the true flowers are unattractive, and would certainly never be noticed on their own merits. However, the flaming red bracts which encircle the small blossoms are so imposing that there are few more striking sights than the Poinsettia in perfection. In the same way the Bougainvilleas have emphasised their small

dull yellow blossoms by encircling them in three bright pink bracts. As a result, this plant is quite one of the most showy features of the tropical forests.

Many flowers are favoured with attention owing to the resemblance they bear to some object which the insect is likely to regard with favour. Nearly all flies are fond of visiting rotting meat or similarly offensive matter, and this tendency has been taken advantage of by many plants. The simulation is kept up, both in the appearance of the bloom and in the smell which it emits. The British Field Iris has been called the "Roast Beef Plant," owing to the curious odour which the flower gives out, although the smell is scarcely so appetising as that of the cooking joint. A Southern European Arum (*A. dracunculus*) is so offensively scented that the plant is hardly a fit subject for culture in the garden. Moreover, the tinting of the flower is of a lurid brown colour, not unlike the colouring of rotting meat. Most remarkable of all, however, are the South American Aristolochias, plants mostly producing huge flowers coloured in brown and white. The form of the flowers of these Aristolochias is also very singular, and in one species long portions trailing away from the body of the bloom give

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SIDE VIEW OF THE FLOWER OF *ARISTOLOCHIA GIGAS*, SHOWING THE TORTUOUS PASSAGE IN WHICH THE FLIES ARE ENTRAPPED.

the impression of drippings from a large piece of meat. As well, the flowers of the Aristolochia emit a horrible odour, which is so nauseating that a person cannot stay long in the vicinity of a blossom. That this simulation is not in vain, may be gathered from an examination of the interior of the bloom, which is crowded with flies in search of the imagined dainties.

Having attracted the insect to the flower, it is necessary to make sure that it does not go away without its burden of pollen. In almost every case of a flower fertilised by insect agency, the pollen grains are either sticky or else covered with excrescences which cause them to adhere readily to any object. As a curious contrast, the pollen produced by wind-fertilised plants is almost always smooth and free from any projections. With a large number of flowers, especially in the case of the Compositæ, the insect visitor in his wanderings brushes up against the anthers of the stamens, and in this way becomes dusted with the pollen, which is likely to be carried to the next bloom visited. The Peacock Butterfly, which sips nectar from the clustered bloom of the Scabious, cannot fail to get a certain amount of pollen over his legs and body. In like manner the bee which blunders into the Crocus blossoms

will, both at her entry and exit, be certain to have her body freely powdered with the golden dust.

In such cases as these we see the relations of the plant and its insect helper at their simplest. Far more elaborate arrangements have been devised to ensure the effective distribution of pollen by insect agency. Many of these are especially remarkable owing to the fact that the flower is designed for the visits of one class of insect, or perhaps for a single species. Thus a number of exotic plants which are introduced into British gardens can never be effectively cross-fertilised, simply because none of our indigenous insects is fitted for the task. A rather curious case is that of a Brazilian species, *Araujia albens*, a plant which is of fairly easy culture in the south of England. In its native country the cross-pollination of the *Araujia* is carried out by large humble-bees, strong enough to force their way in and out of the curious trap-like contrivance which guards the pollen masses. In other places, however, where the plant has been introduced, the flowers are largely visited by moths, which, unaware of the curious device, thrust in their probosces in search of the nectar. Too late the unfortunate insects find that they are caught in

a trap from which they have not sufficient ingenuity to release themselves. So they flutter away their lives in vain endeavours to escape.

Undoubtedly the largest number of special arrangements in flowers have been made with a view to the reception of bees. In whatever way these extraordinary relations have arisen, the plant could scarcely have secured a more industrious and systematic worker. It has been computed that an average bee will visit three or four hundred blossoms on a summer day, so that even where flowers are in great profusion we may take it that not one will escape attention from the winged visitors.

The way in which many flowers have been specially designed in order to keep out unwanted callers has been dealt with elsewhere, but it is interesting to consider the ease with which the right visitor can obtain an entrance. Most people must have watched a humble-bee open that "strong box," the Antirrhinum flower. How convenient is the little platform on which the insect may alight and secure a firm hold with her legs in order that the contrivance may be forced open! Even as the bee takes her measure of the nectar, she receives a dusting of pollen from the anthers. More ingenious still is the arrangement

in the case of the Pea. In this flower the stamens and pistil are contained in a process formed by two petals joined together, generally spoken of as the keel. At a certain stage in the development of the blossom, the anthers discharge their sticky pollen into the cavity at the tip of the keel. Now it is just at this time that the Pea makes its greatest effort to attract attention; the standard is fully spread, the fragrance given out is at its strongest, whilst the supply of nectar is all in readiness for the expected visitor. At last the bee alights, taking up its position on the two lateral petals while it prepares to feast at the banquet. The weight of the insect at once depresses the keel of the flower, and the style, being a fixture, is forced through the hole at the end of the process. Now the end of the style has been provided with a brush, and this in its passage through the conical part of the keel becomes plentifully laden with pollen. Naturally the underneath part of the bee is well dusted with the yellow grains, and the stigma of the next flower the insect calls at will be certain to receive a share of pollen from the last bloom visited.

By an equally ingenious device the Sage blossom ensures that the bee shall not fail to act as an agent for the transmission of its pollen to another

ORCHID.

flower. Here, again, we find a convenient little platform on which the insect may alight. As is the case in so many flowers, the anthers and the stigma mature at different times. The stamens of the Salvia are arranged in the form of a very curious contrivance. The anthers, instead of being affixed to the filament of the stamens in the ordinary way, are arranged on a connective in the form of a swinging rod. When the flower is ready for the reception of the insect the movable rod is in an upright position. Now the nectaries are situated deep down in the flower, and the bee in her search for the sweet stuff must needs come in contact with the terminal knobs of the connective. Thus the rod is forced round, and the anther lobes at the other extremity deposit their pollen upon the back of the insect. The style of the Salvia is in the hood-like portion of the flower, and until its time for maturing arrives it is comparatively short; as its development proceeds, however, the organ extends downwards. If the next Salvia blossom visited by the bee should be in the female state, the stigma will be in just the position to meet the back of the insect which has previously been dusted with pollen. In this way the cross-fertilisation of the flower is secured.

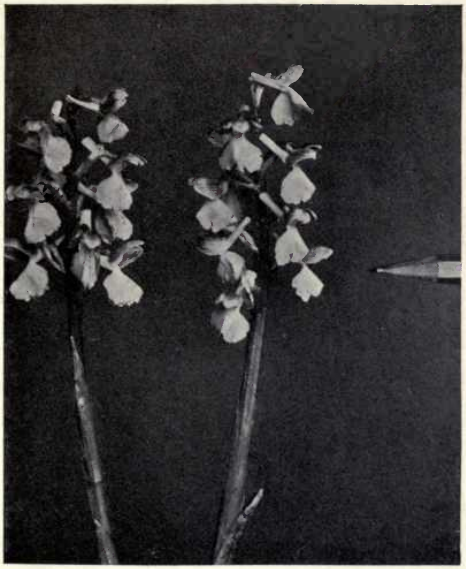
In considering the question of cross-fertilisation by insect agency special attention must be directed to the Orchids. If it can be contended that complication of design is typical of a high order, then we must place the flowers of these strange plants in the forefront. The very formation of the Orchid blossom is so intricate that it is not at all an easy matter to distinguish the different parts.

In the typical Orchid flower we find three fairly distinct sepals, although even here the two lateral ones are sometimes joined together over the interior part of the flower. The petals are also three in number, one of which is frequently much larger than the others, and forms a curious pouch which projects well forward. Even the essential organs have undergone some remarkable modifications, so that it is quite impossible to recognise any stamens as such, while the pollen is produced in two bag-like contrivances which are united to the stigma. As might be expected, the means by which the cross-fertilisation of such a complicated flower is carried out present many points of interest.

The story of the cross-fertilisation of the Early Purple Orchis (*Orchis mascula*) is one of the most fascinating in the world of plants. An

THE NECTARIES OF THE CUCKOO FLOWERS ARE AT THE BASE OF THE TWO SHORT STAMENS.

WHILST THOSE OF THE BUTTERCUP ARE AT THE BOTTOM OF THE PETALS.



THE POLLEN MASSES MAY BE REMOVED FROM THE FLOWER OF THE PURPLE ORCHIS ON THE POINT OF A PENCIL.

examination of the flower will show that the petal forming the lip is carried backwards into a spur which, although it contains no nectar, is valued as a food substance in itself by bees. Now the head of the insect in search of the succulent tissue comes into contact with two sticky disks attached to the stalks of the pollen masses; so that when the bee emerges the pollinia are carried away. At first the pollen masses stand erect, but in about half a minute, owing to a beautiful arrangement whereby the base of the stalk contracts, they incline forward. Thus by the time the bee has arrived at the next flower the pollen masses are in such a position that they cannot fail to strike the stigma. The manner in which the pollen masses are attached to the head of the bee may be well seen if the point of a pencil is inserted into the cavity of an orchid flower, and then gently drawn away.

It is not always that the plant, after attracting the insect to pay a visit, is willing to let the creature take its departure at once. In the case of *Aristolochia clematitis,* gnats and other insects are sometimes held prisoner for sixty hours until the work which is required of them has been performed. The essential organs are contained in a kind of bulbous swelling at the base of the flower,

to which entrance is only possible through a narrow tube. This passage-way is lined with stiff bristles pointing downwards, through which the incoming insects are easily able to force their way. When the flies arrive the stigmas are in readiness to receive the pollen which the visitors will bring with them; meanwhile the insects are regaling themselves on the tissue which forms the walls of the apartment in which they are really prisoners. When they think they would like to depart and make attempts to fly up the tube, it becomes evident that no escape is possible through the hairs, which completely bar the way. It is not until the end of three days, when the anthers have come to perfection, that the barrier dries up and the captives are allowed to go on their way, well dusted with pollen in their frantic efforts to escape.

Among our hedgerow plants the common Cuckoo Pint affords an interesting study of the way in which insect visitors are held captive. Without pulling aside the greenish spathe of the Arum it is impossible to see the true flowers, which are clustered round the base of the upright column called the spadix. At the bottom of all are to be found the female flowers, and just above them is the ring of male blossoms. Higher still we find

POINSETTIA PULCHERRIMA, FROM SOUTH AMERICA.
The bracts surrounding the insignificant flowers are flaming crimson in colour.

PASSION FLOWERS ARE LARGELY FERTILISED BY HUMMING BIRDS.

a mass of hairs pointing downwards. The ovary-bearing blossoms mature first, and at that time give out rather an unpleasant odour which is peculiarly attractive to flies. The insects arrive in numbers, many of them well dusted with pollen from other Arums which have been visited, and find it an easy matter to go down through the palisade of hairs. After visiting the female flowers, each of which produces a drop of honey, the little visitors do not find it such a simple business to escape upwards through the array of hairs. Indeed, it is not until the stigmas have withered, and the anthers have come to perfection, dusting the flies with pollen, that the fringe of bristles dries up and allows the flies to go about their business once more.

It is known that humming birds play a considerable part in the fertilisation of many tropical American plants. By their peculiar habit of flight, these little birds are well adapted for hovering over blossoms and sipping the nectar from the blooms with their long beaks. A great variety of flowers appear to be visited by these tiny creatures, although they seem especially to favour the blossoms of the Fuchsia and Lapageria, as well as some of the Passion Flowers.

In Britain a large number of our trees are cross-fertilised by the agency of the wind, and in no cases are the blossoms large or gaily coloured. Most people must be familiar with the long hanging catkins of the Hazel, which as they reach their maturity are among the first signs of approaching spring. These are, of course, only the male organs of the plant, and it requires some searching to find the clusters of crimson threads which represent the stigmas. On a day when the anthers have come to perfection the smallest puff of air blows the pollen in little clouds through the leafless branches, and a certain amount of it is sure to find a resting-place on the female organs and in this way to bring about pollination.

The Scots Pine presents a most striking example of a tree which relies upon wind fertilisation. In the month of June, when the anthers arrive at maturity, we may see the pollen hanging over the branches in dense clouds. The dispersal of the grain from the male flowers to the undeveloped female cones is facilitated by the fact that the pollen is provided with minute wings. At the time when the pollen floats away on the breezes the ovules on the female cones exude a sticky substance, which ensures the retention of

any grains which happen to come in contact with it.

A certain number of plants rely upon water as a medium for the distribution of their pollen. Of this a British marine species, the Grass Wrack, is an example. The pollen grains are here of tubular form, and being of like specific gravity to the water, are conveyed by the currents from the anthers of the male flowers to the stigmas of the female organs.

More strange still is the story of the Italian Eel Grass (*Vallisneria spiralis*), a native of Southern Europe. The male and female flowers are produced on different specimens, and at first both kinds are developed low down, quite close to the roots of the plant. As soon as the female blossoms have nearly matured, however, the long stems on which they are borne (previously packed away in a receptacle) unwind and bring the flower heads to the surface. At this time the submerged male buds become detached and rise to the surface. After a short interval the blossoms open back three sepals, and in this way form a kind of raft upon which they can float about, driven in all directions by the wind. Sooner or later the majority of the little boats will be certain to come to a halt against one of the female blossoms, with the result that the

projecting stamens can discharge the pollen grains upon the waiting stigma. After fertilisation the long stalk of the female blossom coils up spirally, and gradually carries the ovules down to the mud bottom, where the seeds may ripen in safety.

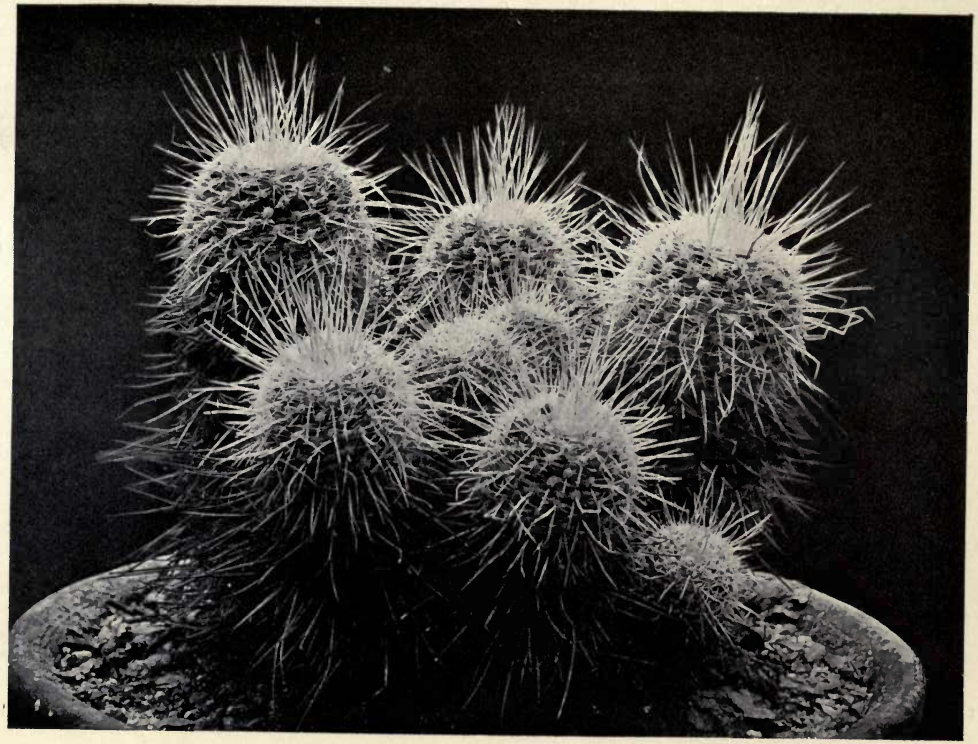
VI

THE PLANT AND ITS ENEMIES

NATURE is, often enough, careless as to the fate of the individual, provided the perpetuation of the race is well assured. There are few instances in which this is so well seen as in the case of many of our common weeds. A considerable number of these species are peculiarly liable to the attacks of animals from which they seem to be ill-protected, yet these plants are always to be found in the greatest abundance. As a matter of fact, the race persists in flourishing, either by sheer vigour of growth or owing to the ease with which the species can reproduce its kind. The amazing vitality of the grasses is an excellent illustration of those plants which within reasonable limits are almost indestructible. For ages the grasses have served as the mainstay of the grazing animals, yet there are few more prosperous species. From the underground stems which so many of these plants produce, a constant supply

of green tufts can be sent up to replace those which have been torn away. In the case of the Groundsel or Chickweed the continuance of the race is assured by the facility with which the little plant can reproduce its kind. Both these species seem to be harmless and sweet-tasting, such as the larvæ of insects, as well as snails and slugs, would delight to feed upon. Yet it is well known that these plants are among the most troublesome pests of our gardens. This is simply owing to the fact that both the Groundsel and the Chickweed come to maturity so quickly, that it is not an uncommon thing for several generations to be brought to perfection in a single season.

The entire animal kingdom lives at the expense of the vegetable world, and to protect the plant against the aggressors many remarkable devices have been called into being. One of the most widespread contrivances for the defence of the plant is the thorn. These spines are very prevalent among many genera, and in the different species, represent modifications of both leaves and stems. The development of the thorn is seen to a remarkable extent in the case of the Cacti, plants which in some ways are more perfectly protected than any others in the world. With many species, particularly among the groups Echinocactus and



A WELL-PROTECTED CACTUS.

Melocactus, the whole plant is covered with spines, which interlace in such a way that no part is left unshielded. A kind of Prickly Pear, well named *Opuntia formidabilis*, produces thorns which are sometimes as much as a foot in length. The desert in which these plants grow contains but a comparatively sparse vegetation, and the juicy stems of the plants would be peculiarly liable to be attacked by hungry and thirsty animals. Indeed, even with its armament of thorns, the Cactus is not absolutely secure. It is said that the Mexican ponies have learnt the art of kicking away the spines with their heels, and then slaking their thirst at the bleeding wounds inflicted on the plant.

It is a very significant circumstance that the production of spines seems to take place to the greatest extent when the plant is growing under adverse conditions. In this connection an exceedingly interesting species is the Rest Harrow (*Ononis arvensis*). As is well known, this plant is to be found fairly common in two varieties, called respectively *O. spinosa* and *O. inermis*. As is implied by the name, one plant is thorny and the other is quite devoid of spines. Now and again both these varieties may be found growing in the same district, sometimes quite

close to one another. It will be seen, however, that the thornless specimen has been more fortunate in its position than the one which is well clad with its defensive armament. In the former instance the little plant has lighted upon a patch of moist, rich soil; whilst in the latter case a hard struggle for existence, in a dry situation, has been the fate of the subject. It is very commonly to be seen that a race of one-time thorny plants will, under cultivation, tend to get away more and more from their spiny character. As domestic subjects, the plants, removed from the fierce fight in the natural world, are no longer in need of protective devices.

Although in many cases serving the same purpose, the prickles often seen upon the leaves and stems of plants are on different lines from thorns, seeing that they are merely excrescences of the cuticle. The hooked prickles of the Brier Rose peel off with the skin, and are quite unattached to the woody portion of the stem. In the Holly, the prickles are to be found springing from the margin of the leaves. It is curious that it is only whilst the Holly is in its shrubby form that the leaves evidence their prickly nature. As soon as the plant attains to the dignity of a tree the foliage is produced with its margins quite unbroken.

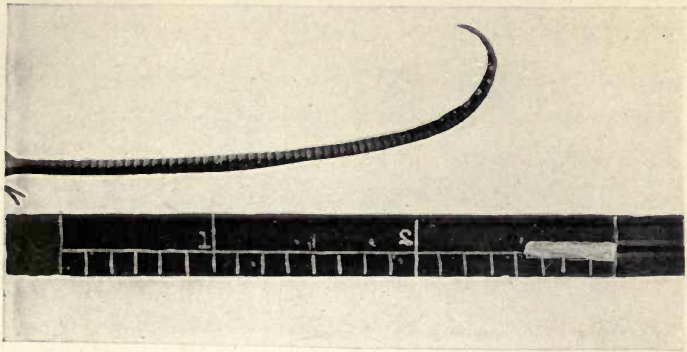
In many large bushes, it is possible to trace the process by which the prickles have been gradually discarded; and from a single shrub an interesting series of leaves may be gathered, commencing with the specimens from the lower branches, which are fully armed, and ending with those from the uppermost shoots, which are quite destitute of any prickles. As in the case of the thorny plants, it is to be noticed that prickles are produced in the greatest abundance when the specimen is having a hard time of it. Thus Brier Roses which have been cut back in hedges send up their fresh shoots abundantly supplied with prickles.

Closely allied to the prickles are the various hairy appendages which are so often distributed over the foliage of plants. The leaves of the Orange Hawkweed, and even the flower stems, are covered with stiff black hairs. Plants protected in this manner are not subject to the attacks of insect larvæ, slugs or snails, as would probably be the case if the foliage were perfectly plain. Similarly, grazing animals are less inclined to regale themselves on leaves which are thickly covered with bristles.

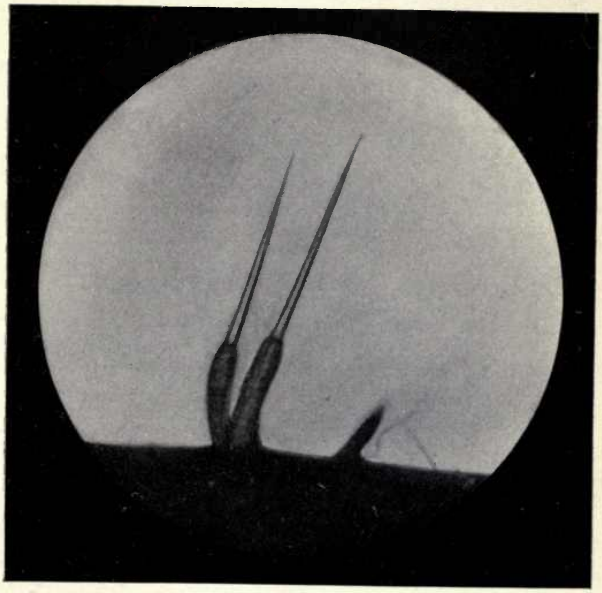
There must be few people who have not suffered at one time or another through coming

into contact with the stinging hairs of the Nettle. Under the microscope it is seen that these stings consist of a long tapering cell, rising from a cushion-like base. The point of the hairs is easily broken, owing to the cell wall being very thin. When the hair comes in contact with any object which the apex can pierce, a slight wound is made, and at the same time the upper part of the bristle breaks, allowing the fluid which the cell contains to escape into the opening. The poison, consisting as it does of formic acid and a property known as enzyme, is of a peculiarly irritating nature—as most people will have experienced to their cost.

Far more formidable, however, are the stings of certain exotic species, one of which, the great Shrubby Nettle (*Urtica crenulata*) of Northern India, is a really formidable plant. This species attains to the height of fifteen feet, and is described by Sir Joseph Hooker as having broad glossy leaves covered with microscopic hairs. The plant only seems to sting violently in the autumn, but at that time the strength of the poison is such that people have suffered from its effects for days. Moreover, at the time of its greatest activity the plant gives off an effluvia which is so powerful that it causes running from the eyes and nose. More formidable still is the *Urtica gigantea* of



CACTUS THORN.



NETTLE STINGS (MAGNIFIED).

Australia, which grows into huge bushes twenty feet or more in circumference. It has been pointed out by Mr. Edward Step that in the foliage of the Common Elm very similar processes to the stinging hairs of the Nettle are to be observed. These are nothing like so formidable as those of the Nettle, but are sufficiently so to cause an annoying irritation to the hands. Of course, the Elm is classed with the same natural order as the Nettle. It seems likely that these stinging hairs serve a real purpose in protecting the young growths of the Elm just at a time when they would be most likely to be damaged by grazing animals.

A singular development is that to be seen in the case of the Cuckoo Pint (*Arum maculatum*). In this case the tissue of the foliage contains thousands of little crystal needles (in addition to a certain acrid poison) which stick into the lips, causing an intolerable burning sensation. This fact may be proved by anyone biting a small portion of the leaf. Whether these crystals are really a protective measure or not, there is no doubt that the plant must often be left alone on account of their presence. The crystals are developed to a much greater extent in the case of certain tropical plants allied to the Arum.

There is little doubt that the development of sour and poisonous juices in certain plants is valuable as a protective measure. This is not invariably so, for certain products such as the tannin in the Oak are merely waste products—the outcome of a definite chemical process. Still in the case of many species it is clear that the plant derives a distinct advantage from its offensive juice, and we can hardly regard its presence as entirely accidental. If we take the strong-tasting plants of the countryside—the aromatic Mint, the pungent Water Cress, the evil-smelling Jack-in-the-hedge, to mention only three examples—we shall assuredly find that these species enjoy a comparative immunity from attack. True enough, as if by way of retaliation, certain insect larvæ seem to have developed a special fancy for some of these species; but, as a rule, the mild-tasting vegetation is much more likely to receive the attentions of marauders.

A very interesting problem which arises in connection with certain species of plants which seem to be specially protected is that of mimicry. The subject is one concerning which we have little positive knowledge, yet some of the instances are so striking that they cannot well be ignored. On the face of it there is, of course, nothing pre-

THE BROOKLIME AND THE MINT.

posterous in the conception of plant mimicry, when we have so well established a theory on the same lines in the case of animals. The common Mint of our brooks, a particularly attractive plant, which sends up lusty shoots in the early summer, is but rarely attacked, doubtless because of its strongly aromatic flavour. Now just at this time the Brooklime, another moisture-loving plant, starts to grow. These two plants, both found plentifully in damp spots, frequently intermingle; and at a little distance it is not an easy matter to distinguish the one from the other, so strong is the resemblance. It does not seem unreasonable to suppose that the Brooklime benefits to some extent by its resemblance to the Mint. Grazing animals cropping the herbage along the banks of the brook, would be likely to leave a plant severely alone which looked so like the aromatic Mint. Lord Avebury has pointed out the close similarity existing between the Scentless Mayweed and the Chamomile, both as regards leaves, flowers, and general habit. The latter species has a strong bitter taste which is likely to serve as a protection, and in its resemblance the Mayweed may possibly reap advantage. Of course, these last two plants are so closely related to one another that one should not

perhaps attach too much importance to the likeness.

Far more remarkable than the instances of possible mimicry already mentioned are the large number of plants bearing a more or less striking resemblance to the Stinging Nettle, which, we must remember, is one of the best protected species in this country. This simulation is seen to its greatest advantage in the case of the so-called White Dead-Nettle (*Lamium*), a plant which is not even remotely allied to the Stinging Nettle. Especially is the likeness to be observed in the early stages of growth, before the white blossoms of the *Lamium* have been developed. Indeed, it is only after a critical examination that it is possible to tell the difference between the two plants, when, as is often the case, they are growing closely together. It is surely not an unreasonable supposition to suggest that browsing animals, and possibly even insect larvæ, may be deceived, and may pass over the harmless plant under the impression that it is the baneful one. At any rate, after a few experiences with the Stinging Nettle, one can hardly imagine an observant creature venturing to meddle with anything that at all looked like the obnoxious weed. As has been suggested, there are quite a

number of plants which bear a fair similarity to the true Nettle, such as the Red and the Yellow Nettle, the Betony, the Gipsywort. One can scarcely think that it is entirely chance which has ordered this remarkable repetition of one suggestive form.

Whether anything which may be called protective resemblance exists among plants is at present an open question, but certain succulent species are very curious in this connection. The most striking of these plants is *Mesembryanthemum truncatum*, a South African species which flourishes in desert regions. The whole of this quaint vegetable consists of succulent shoots which grow close to the ground, and these so strongly resemble the stones among which they nestle as to be most perfectly hidden. Even after a close examination it is impossible to distinguish the plant from the stones. Several allied species are also remarkable on account of their rock-like appearance, which, whether it be accidental or not, can hardly fail to cause the plants to be overlooked time and again. A few of the Cacti may also be said to bear a strange resemblance to their environment, most striking of all in this direction being the *Cereus monstruosus*. This plant, which produces oddly-shaped stems, is coloured in such

a dull brown manner that it does not look in the least like a growing vegetable.

It is often in the very beginning of a plant's existence that the most need arises for protective means. It is therefore not surprising to find quite a number of seeds which may be regarded as examples of simulation. Doubtless many of these resemblances are purely accidental, but in others one cannot but think that there is a real purpose in the resemblance. Many seed vessels bear an astonishing likeness to beetles and other insects. In a leguminous plant which is called *Scorpiurus* the pods so closely resemble a centipede that even an experienced eye is deceived at a distance. In the same way the seeds of the Castor Oil Plant (*Ricinus*) are very much like a small beetle, and the resemblance is still more strong in the seeds of some of the species of *Jatropha*. More remarkable than any of the instances mentioned above are the large seeds of the genus *Chelonospermum*, plants indigenous to certain of the Pacific islands. These most wonderfully resemble the giant coleoptera, which are such a feature of insect life in this part of the world.

One can well understand that granivorous birds, which would tear these seeds in pieces and

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INK-BOTTLE OR URN-SHAPED FLOWER OF THE WHORTLEBERRY, SPECIALLY DESIGNED TO EXCLUDE CREEPING INSECTS.

destroy them, might mistake them for very formidable beetles, and thus leave them alone. In much the same way the smaller seeds might be left alone by grain-eating birds, under the impression that they were insects. In passing, it may be pointed out that in the case of these latter it might be an advantage for them to be swallowed by birds, provided that their external coating was able to withstand the action of the digestive juices. Thus the resemblance which they bear to small insects would make them attractive to insectivorous birds, and even if the winged creatures did not actually swallow the seeds, they would probably be sufficiently interested to carry them a little distance before the mistake was found out.

The good things with which the flower is stored are not intended for all comers. The matter is viewed in rather a different light, however, by certain insects who seem to regard the feast as having been specially prepared for their delectation. To ward off the attacks of these plunderers has called for no little ingenuity on the part of the plant. There is little doubt that the shapes of certain flowers have been modified largely for the purpose of excluding small creeping insects. The urn-shaped blossoms of the

Whortleberry secrete their honey right at the base of the corolla, where it can only be reached by long-tongued insects. Even if a creeping visitor could negotiate the rounded sides, it would not be able to enter the flower, so narrow is the opening.

Many plants bearing flowers in which the nectaries and pollen are fairly accessible arrange to prevent creeping insects from getting near to the blossoms at all. The stems of not a few plants are densely covered with minute hairs, which render it almost impossible for crawling insects to mount up to the flower. In some instances the hairs all point downwards, and this is to be observed in the case of certain grasses; if the thumb and finger are moved up the stem a very perceptible roughness may be felt, which is absent when the stem is passed in an opposite direction. In other cases it is not until the visitor actually arrives at the flower that he is confronted with the barrier of hairs. In the case of the common Cornflower the stems and leaves are quite destitute of prickles, but the involucres forming the flower head are bordered with formidable teeth. The lip of the Foxglove is covered with long bristles which guard the entrance to the flower. These do not

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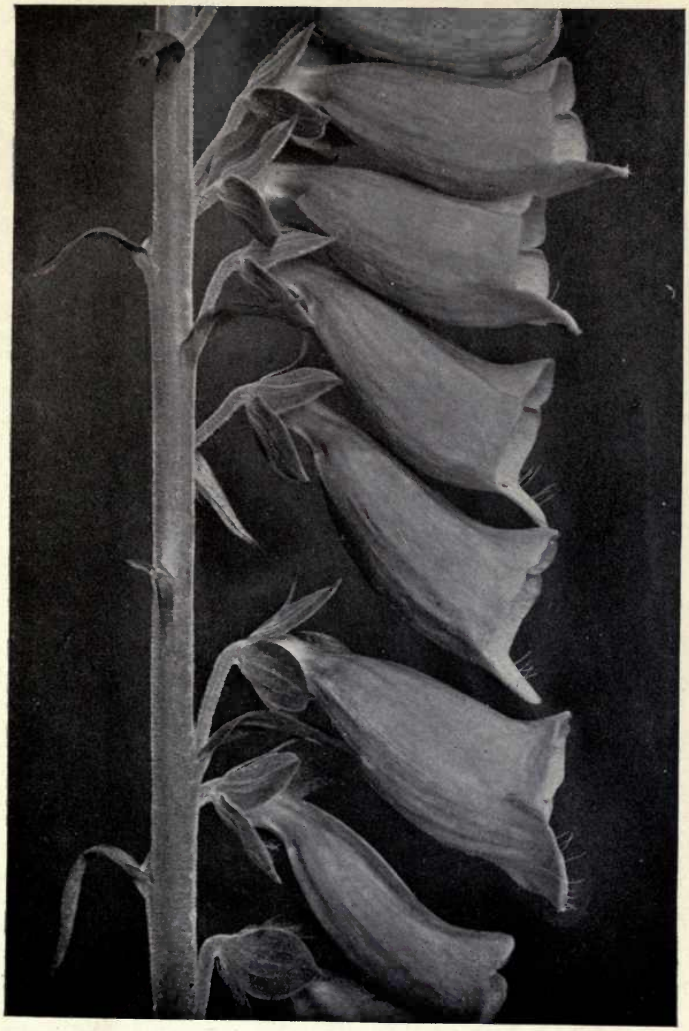

HAIRS ON FOXGLOVE'S LIP TO EXCLUDE UNWANTED VISITORS.

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seem to trouble the humble-bees, which appear to be the only legitimate visitors to the flower. In the case of quite a number of plants, even the filaments of the stamens are clothed with hairs that form barriers in the way of tiny insects which would mount to the pollen-laden anthers. This is seen to a certain extent in the case of the Crocus, and to a much greater degree in the flower of the Bog Asphodel, where the stalks of the stamens are quite "furry" in appearance.

In a certain number of instances the presence of glandular hairs secreting a glutinous substance makes it difficult for creeping insects to get anywhere near to the centre of the flower. This is to be observed in the blossoms of the Gooseberry, and of the *Linnæa*. The calyces of the Plumbago and Honeysuckle are so thickly adorned with glandular hairs that small insects not infrequently get stuck fast when trying to approach the flower. This is seen to a much greater extent in the case of the *Silene nutans*, well named the Catchfly. Here the upper part of the stem, as well as the calyx, is viscid, and large numbers of small insects are to be found dead and dying upon the glutinous surface. Just at the time when the Rhododendron flowers are at their best the stem is peculiarly

sticky by reason of a mucilaginous substance which is exuded. On this it is possible to find almost any number of little creatures which are captured whilst endeavouring to reach the blossom.

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FOXGLOVE.

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VII

THE FEELINGS OF PLANTS

QUITE a short while ago the vegetable world was considered to be something very distinct from the animal kingdom. The difference between the two living creations appeared to be so sharply defined that the idea of any connection seemed to be entirely out of the question; at any rate, such was the view of the matter to those who were content to take a mere external survey. It is now, of course, well known that in the primal forms of existence plant and animal so closely resemble one another that the keenest investigation fails to establish any line of demarcation. Indeed, the same basis is responsible for the manifestation of life equally in the vegetable and the animal. In the green chlorophyllian tissue of the plant can be recognised the wonderful protoplasm, no less than in the specialised nervous system of the animal. This being so, it is a matter of great interest to consider the response of the living

matter in the vegetable to external stimuli, and thus find further evidence of the intimate relations between all living things.

In the old days it was often suggested that plants cannot feel, although on what grounds the assertion was made it is not easy to see. Reduced to its simplest possible form, the ability to feel merely indicates the power of response to a stimulus. The iris of the human eye is so delicately adjusted that it can feel the influence of light, closing in round the pupil when an increase in the amount of illumination takes place, and contracting when the light-rays are few in number. It is easy to prove that a plant can feel the light. Place a healthy specimen in front of a window in such a position that the light can only reach it from one direction. In a few days the growth of the plant is entirely altered; its upright bearing goes, and it leans over so that the upper surface of its foliage may be fully exposed to the stimulating rays. The same point may be very strikingly illustrated if a small collection of seedlings is grown in a box with a single aperture, when it is seen that all the young stems turn towards the path of the light. Some little plants are astonishingly sensitive even to very feeble illumination.

Darwin showed that the cotyledons of Phalaris became "curved towards a distant lamp which emitted so little light that a pencil held vertically close to the plants did not cast any shadow which the eye could perceive on a white card." In another experiment it was shown that if seedlings kept in a dark place were laterally illuminated by a taper for a minute or two at intervals of three-quarters of an hour, the little stems leaned over to the direction from which the intermittent light had come. Normally the extreme sensitiveness of leaves to the action of light is well seen in the case of climbing plants, particularly when the specimens are growing up a wall. Even though the effort may entail considerable distortion of stalk, the leaves are invariably brought round so that the face of them is held outwards. It is easy to understand that it is to the advantage of most plants to bring their foliage into such a position that a maximum amount of light is secured.

Movement towards the light is not an invariable feature in the organs above ground of all plants. In the case of the Ivy there is a distinct tendency for the shoots to bend away from the light. More strange still is the behaviour of the tendrils of the Vine and Virginian Creeper. These

processes always shun the brightly illuminated quarters, and seek out the dark parts. The phenomenon is all the more remarkable when it is remembered that in origin these tendrils are modified leaf-shoots—portions of the plant which in the ordinary way would certainly not turn away from the light. That the tendrils are more likely to obtain a hold by directing their growth to the dark cracks and crevices than if they grew out to the light is, of course, obvious. A most curious instance in which the same part of a plant is affected by light in different ways at different times is to be seen in the case of the Ivy-leaved Toad-flax (*Linaria cymbalaria*). The flower-stalks at first incline towards the light, but as soon as the blossoms have been fertilised the stems turn in an opposite direction and so bring the capsules into a position for planting the seeds in the crevices.

On occasions the foliage of the plant is seen to shun the light. It is noticed by all travellers that the Australian forests offer very little shade; this is simply due to the fact that certain of the trees (particularly the Eucalypti) hold their leaves edgeways to escape the fierce rays of the sun. It is curious that the seedling Eucalyptus trees bear their leaves laterally. Of course, these young specimens growing in the partial shade afforded

by their parents are not likely to suffer harm from the sun's rays. The so-called Compass Plant (*Silphium*) has leaves which twist laterally when the sun shines upon them, and in this way avoid the injurious effects of too strong an illumination. Many plants under the influence of very strong sunlight droop their foliage; partly, of course, because of the excessive transpiration of moisture; but we may take it that the change in position is a useful protective measure.

As to the causes which underlie these light-seeking and light-avoiding movements, we cannot find any all-sufficing explanations. Certain it is that they only continue so long as the plant is in a growing state. We know that light has a retarding influence on growth, and it has been suggested that plants lean towards the point of illumination because the shady side of the stem extends more rapidly than the part which is strongly lighted. This theory does not help us to understand how it is that parts of the plant avoid the light. One cannot but feel that in all these phenomena there is something more than a mere mechanical adjustment, and that most of these responses must be the outcome of inherent tendencies which exist in the plant. Whilst a little observation destroys the illusion that the

Sunflower always follows the sun, there is no doubt that the plant, in common with a large number of species, does move its blossoms towards the glowing orb.

This is perhaps particularly noticeable in the case of composite plants. The Common Hawkweed, which grows so abundantly in our fields, leans its blossoms over very distinctly to the sun. Thus an observer standing with his back to the south sees the field as a blaze of gold, but turning in an opposite direction there is nothing to be noticed save the backs of the flowers. Much the same kind of thing is to be seen in many species of Anemone. On a brilliant day it is observed that the copse appears to be starred all over with the white flowers of the Wood Anemone, but with a slight change of position the flowers seem to disappear, simply because the blossoms are all fronting in one direction.

The Sensitive Plant is a species with many interesting points. This curiosity goes to sleep every night, but, of course, the most striking feature of the plant is its extreme sensitiveness to contact. As is so well known, the lightest touch is sufficient to make the leaflets close upon their support, the petiolules to draw up

THE SENSITIVE PLANT.

SENSITIVE PLANT AFTER CONTACT.

together, and the leaf-stalks to collapse. The most singular feature is that the shock may be communicated to other parts of the plant, and even, at times, to the whole specimen. The Sensitive Plant has something which is strangely like a rudimentary nervous system, in that it would seem that there is a continuity of susceptible matter throughout the whole specimen. There is little doubt that the contractile power resides in small cylindrical cushions—pulvini—which occur at the points of insertion of the leaf-stalk with the stem.

A pulvinus is a process containing a woody centre surrounded by spongy cells rich in water. Now, when one of the leaflets of the Sensitive Plant is touched, the effect is transmitted, probably by the threads of protoplasm passing through the cell wall, to the pulvinus. The outcome of the reception of the shock is that the water passes from the cells on the lower side of the process to those in the upper part, and, as a consequence, the former portion becomes flabby and is no longer able to support the leaf-stalk. Thus the organ falls by its own weight. After an interval the water in the cells regains its original distribution and the leaf assumes its normal position.

It is only during the period of active growth that the Sensitive Plant exhibits great susceptibility. Moreover, a high temperature seems to be an essential feature of a prompt response to touch on the part of the specimen. Up to a certain point the Sensitive Plant seems to be able to become accustomed to shock. A curious experiment was conducted many years ago in which a young specimen of the plant was placed in a carriage. Directly the vehicle started to move the plant drooped its leaves, but as the movement continued, the effects of the shock became less and less until something like a normal position was assumed.

Certain plants are curiously responsive to electrical influence. One of the most remarkable of these cases is that of the *Abrus precatorius*, an Indian leguminous plant. The behaviour of this species has given rise to a good deal of speculation from time to time, and it has been claimed that warnings of the approach of magnetic storms and electrical disturbances may be gathered by a close observation of the position of its leaflets. This is certainly crediting the plant with powers which it does not possess, although there is no doubt that the Abrus is responsive to the variations in illumination, temperature, etc. It is

doubtful whether the plant is more sensitive in this way than the Mimosa. A young specimen, which the writer had in his possession, evinced considerable leaf agitation during the progress of a thunderstorm. Almost all these sensitive plants are very much affected when exposed to the vapours of an anæsthetic; in this instance the foliage assumes the position which it takes up at night.

The Telegraph Plant (*Desmodium gyrans*) has well been called one of the most curious in the world. Certainly it presents a problem which has completely baffled all scientists. The leaves of this species are divided into three parts, consisting of a large leaflet and two smaller lateral ones. It is these latter which offer a strange phenomenon, and one which is not at all easy to explain. Practically throughout the whole of their existence these leaflets are in motion, executing little jerks, which suggest the movements of the seconds hand of a watch. When one of the leaflets rises the other descends, each in its turn describing a kind of elliptical course.

These movements occur throughout the life of the plant, although the greatest activity is evinced by the leaflets during humid days when they are under the influence of bright sunshine.

The duration of each movement varies from about one and a half to three minutes, and if a leaflet should be restrained for a while, the rate of travelling is very much increased. Although it is nothing like so perceptible, the larger leaflets also change their position, moving first to the right, and then to the left, with a slow, continuous movement. The most singular point about the jerks of the leaflets of the Telegraph Plant is that they seem to occur quite spontaneously, and not in response to any external stimulus. The explanation of this strange phenomenon is still wanting, neither is it easy to see that the plant derives any benefit from its remarkable habit. Specimens of the Telegraph Plant are to be seen in most botanical gardens.

Among the insectivorous plants there are to be found some striking instances of plant sensation; indeed, certain of the species are very highly specialised in this direction. The Droseras, or Sundews, are well-known little plants found in various parts of the world, the genus being represented in Great Britain by three examples. The Round-leaved Sundew (*D. rotundifolia*) is found commonly in boggy places. The plant, although small, is rendered somewhat conspicuous on account of its rosettes of bright-red leaves. It

is worth while to examine the foliage rather closely. The leaves are seen to be covered with clubbed hairs, at the ends of which are produced sticky glands.

It is strange that the foliage of the Sundew seems to have a peculiar fascination for flies and other insects, albeit that these little creatures, as a rule, pay a heavy penalty for their curiosity. So sensitive are the hairs on the Sundew leaf that the struggles of a fly held by the sticky secretion induce the processes to close round the unfortunate victim, so that escape is quite out of the question. At the same time these movements are accompanied by an excretion of a digestive fluid which aids the leaf to assimilate the nitrogenous matter in the body of the fly. Another curious feature in the behaviour of the tentacles of the Sundew leaf is that they entirely fail to respond in any way to drops of water which are allowed to fall on the foliage. As well, too, it is remarkable to note that small stones do not stimulate the leaf to any great degree of activity.

Even more remarkable than the Sundew is the Venus Fly-trap (*Dionæa muscipula*), a little plant which is a native of the swamps of Carolina. The leaves of this plant, which mostly lie

out flat on the soil, are composed of two very distinct parts, a stalk and a blade. The stalk, a leafy expansion which really performs the functions of ordinary foliage, is joined to the blade by a narrow neck. The blade is formed of two plates which are united by a rib fashioned somewhat on the lines of a hinge. The outer edges of the plates are furnished with borderings of rough bristle-like hairs. The sensitive part of this little trap exists in three cilia arranged in triangular fashion on each half of the blade. To touch one of these never so lightly is to induce a rapid closing of the little apparatus; the plates snap up together, the fringe of hairs interlocks—the whole proceeding strongly suggesting the shutting of a very perfectly contrived trap.

Now, if the object which comes into contact with one of the sensitive hairs should happen to be a fly, the result is, of course, disastrous for the unfortunate insect; no escape is possible for the victim, whose body will be retained by the *Dionæa* leaf until the desired nutrient properties have been absorbed. In order to attract the flies, it appears that the upper surfaces of the plates are furnished with certain small glands which secrete a viscous fluid peculiarly alluring to insects. It is singular that no other part of the leaf of the Venus Fly-

VENUS FLY-TRAP, SHUT.

VENUS FLY-TRAP, OPEN.

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trap is at all responsive to contact. The back of the organ, even the surface of the plates themselves, may be touched; but unless one of the bristles is jarred the little trap remains immovably open. Experiment with this strange plant showed that whilst the blades would enclose small pieces of stone, for instance, yet these would not be retained for any length of time. A short while after acceptance, the blades will slowly open and permit the undesired substance to roll away.

There is no doubt that there is a great deal in the behaviour of roots which it is not at all easy to explain. Indeed, Darwin went so far as to say that the tip of the radicle, in its power of directing the movements of adjoining parts, acts like the brains of some of the lower animals. Much that the growing roots accomplish, however, is the outcome of simple circumstance. We are no longer puzzled, as were the old botanists, by the manner in which roots will seek the damp portions of the soil. The additions to growing roots will take place along the line of least resistance; this will naturally be through the soil which has been loosened by water. In this way the roots will ultimately arrive at the source of the moisture.

Other problems presented by roots are not

nearly so simple, and lead one to the conclusion that these organs may be able to feel at a distance. The roots of trees will not infrequently force their way in between the brickwork of wells some distance above the water level, finally spreading out downwards until their growing points are completely immersed. A little fern, which the writer had in his possession, was most interesting in this connection. The plant was growing in a pot which always stood in a saucer of water. It would seem that the supply of water was not sufficient for the needs of the specimen. On this account the plant actually sent down a root on the *outside* of the pot to the water in the saucer beneath. It is sometimes noticed that the roots of tropical Aroids, such as the Monsteras, when grown under glass, are very clever in directing the growth of their roots towards water tanks which may be beneath them.

A very singular case of root perception, and one which it is interesting to recall, is recorded by Carpenter. He tells us that in a hollow in the upper part of an old oak, the seed of a Wild Service Tree was accidentally sown. After the germination of the seed the little plant grew for a while in the decayed vegetable mould collected in the opening. As the young tree increased in

LITTLE FERN SENDING DOWN ROOT ON OUTSIDE OF POT TO WATER.

BOUGAINVILLEA, AN INTERESTING PLANT WITH LILAC COLOURED BRACTS ROUND INSIGNIFICANT FLOWERS.

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size, however, the need for more room made itself felt, and accordingly an attempt was made to reach the ground. The roots were sent down inside the stem of the tree, which was hollow. In the soil to which they directed their growth there was a large stone—about a foot square. If the direction of growth had remained unchanged, the roots would have simply come right down on to the stone. Strangely enough, about half a yard above the stone, the roots divided into two parts; thus when reaching the ground the soil was penetrated on either side of the obstruction. It is not at all an easy matter to offer an explanation of a phenomenon of this nature, which in slightly different forms is not an infrequent occurrence in some of our older forests.

VIII

THE EVOLUTION OF THE FLOWER

In a general way, without the system of organs to which has been given the name of flower, the blossoming plants could not continue to exist. Of course, there are exceptions where plants producing flowers are not entirely dependent upon the offices of the floral organs for the perpetuation of their kind. Naturally, all annuals rely entirely upon increase by seed, but there are a few known cases in which perennial plants have persisted in a locality, and extended their field of growth, without ever having been known to propagate their kind through floral agency. The most singular instance on record is that of a little Oxalis introduced into Malta from the Cape before the year 1804. The species has spread along the shore of the Mediterranean by means of bulbs, but has never yet been observed to set seed in Europe.

A more homely instance of a plant which is

IN THE PEONY THE LEAF ORIGIN OF THE CALYX IS CLEARLY SEEN.

practically non-seeding is to be found in the Lesser Celandine—a species which only on the rarest occasions produces fertile seed. The common mode of increase adopted by this plant is to be observed if the axils of the leaves are examined just after flowering time. In each recess there will be found a curious little tuber about the size of a grain of wheat. These will subsequently fall to the ground, and, taking root, produce new plants. We must regard instances such as these as exceptions to that which is the rule amongst plants producing flowers.

Seeing that the flower is such an important feature of the plant, it is a matter of interest to consider the relations of the blossom to the other parts of the typical specimen. For the present purpose it will be all-sufficient to think of the flower as consisting of four parts. Starting from the outside of the bloom, we find the calyx; this consists of a number of sepals, which may be green or coloured. Enveloped in the calyx is the corolla formed of a number of petals usually coloured to a greater or less degree. In the centre of the flower we shall find a number of stamens, these enclosing in their turn the group of carpels which go to make up the pistil. As well, in not a few flowers, there are present a

number of external appendages to which has been given the name of bracts.

It has been stated that the calyx of the flower is in some cases green, whilst in other instances it is coloured and petal-like. To state that the sepal is green is the same thing as saying that the organs to an extent perform the functions of a leaf, and it is interesting to see whether it is possible to trace any further connection between the calyx and the foliage of the plant. The herbaceous Peony is well worth an examination with this problem in mind. If a number of specimens of this flower be examined, it will be found that quite often the sepals of the calyx are modified leaves. Indeed, time and again it is impossible to determine definitely the exact nature of the organs, and the confusion is all the greater when, as is often the case, a large area of the leaf-like sepal is as gaily coloured as a petal.

In the common Moon Daisy of the meadows we may trace the whole course of the evolution of the green bracts which encircle the mass of ray florets. If one of the long-stemmed blossoms be examined, it will be found that, starting from the base, where there are the typical leaves of the plant, we shall find that there is a steady

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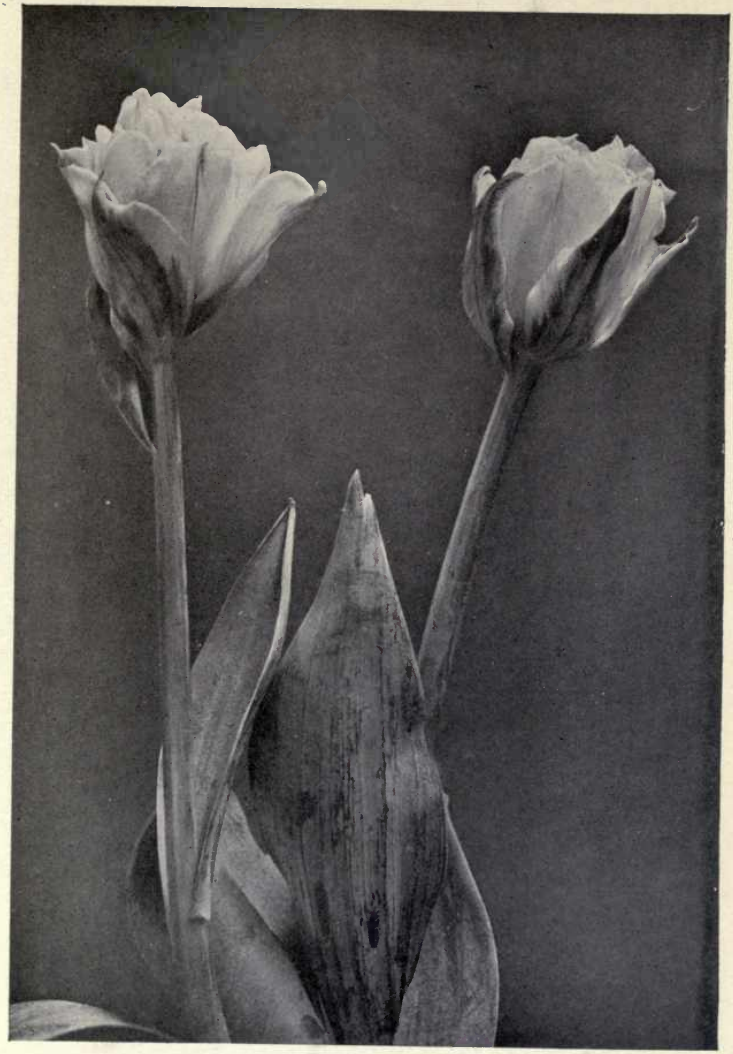

LEAF-LIKE SEPALS OF TULIP.

decrease in the size of the foliage as we approach the flower head. Finally the green processes lose their distinctive form altogether, until just below the flower they drift into simple lobes, which bear a striking resemblance to the bracts that encircle the flower.

We can thus trace a definite connection between the sepals of the flower and the foliage of the plant. Going beyond this, it is not a difficult matter to find a distinct relationship existing between the calyx and the corolla. The Tulip is an excellent case in point, for except that the sepals are, of course, on the outside of the petals, there is really nothing to distinguish them. Now, if we observe a large number of cultivated blossoms we shall certainly find that in not a few cases the sepals are partly or wholly green, proving beyond a shadow of a doubt whence they have their origin. Perhaps a still more striking proof of the leaf origin of both sepals and petals is to be seen in the flower of the Snowflake (*Leucojum æstivum*). Each portion of the perianth is tipped with a dot of pure green, and this spot stands up in vivid contrast to the snowy whiteness of the organ. For what special purpose this conspicuous marking of green may have been retained it is not easy to say; it is all-sufficient to indicate

to the student the leaf ancestry of the sepals and petals.

A singular example of a plant belonging to an advanced family which has not found it necessary to produce any coloured sepals or petals for its flowers at all is to be seen in the Green Rose (*Rosa viridis*). As the name of the plant suggests, it is entirely without any tinted blooms, all parts of the flower being in the form of small green processes. If examined closely the organs are seen to be nothing more than diminutive leaves, and these even go so far as to retain the toothed edges which are such familiar features of rose foliage.

The change of the leaf into a tinted sepal or petal is not, after all, such a very remarkable happening, for coloured leaf-like organs, which exhibit their character in all respects save that they are not green, are not uncommon. One of the most striking plants exhibiting this change of colour in the leaf is the *Bougainvillea glabra*, examples of which are to be seen fairly often in greenhouses. The real bloom of the Bougainvillea is insignificant, nothing like so striking in appearance as our Cowslip. They are developed in clusters of three, and, being of a pale yellow, would scarcely be noticed amongst the foliage

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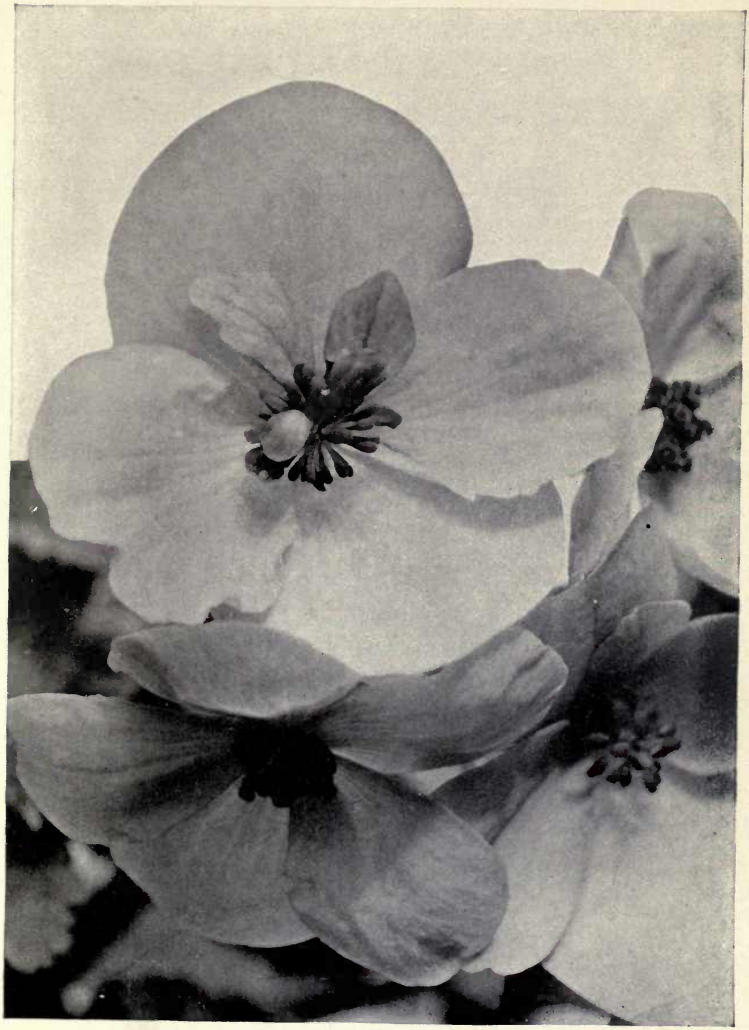
THE SNOWFLAKE, SHOWING GREEN TIPS ON FLOWERS.

were it not that each group is enveloped by three conspicuous bracts. These bracts are closely on the lines of leaves, but are tinted in a highly attractive shade of lilac. As has been indicated in an earlier chapter, the Bougainvillea is well able to attract the attentions of insects by means of its showy appendages. A more familiar case of extra floral coloration is that to be seen in the *Salvia horminum rubra*, a common garden species. This plant has adopted strange means to advertise the presence of its small labiate flowers. When in bloom the terminal leaves of each spike of this Salvia are tinted in the brightest pink. There is no doubt that these processes are true leaves, seeing that when traversing the whole of the stem it is possible to find leaves which are half green and half pink.

Further proof that the petals and sepals of the flower have their origin in the foliage of the plant is to be seen in the case of those species in which the calyx or the corolla persists after the blossom is "over," and for a time practically performs the offices of leaves. Thus with the Christmas Rose the petal-like sepals which go to make up what one may call the corolla, are peculiarly tenacious in retaining their position on the stem; they do not fade away after the maturity

of the essential organs, but lose their whiteness and become green and leaf-like in appearance. Much the same process goes on in the case of the Hydrangea, a plant which, it is well known, surrounds its inconspicuous flowers with showy bracts. These bracts remain for a long time after the flower has faded, finally becoming as green as the leaves of the plant itself. Moreover, there are certain species of plants in which the coloured parts of the flowers gradually develop from very green material. This is seen in the case of some of the Guelder Roses (*Viburnum*), where the undeveloped floral appendages practically perform the offices of leaves during the early stages of their existence.

The conspicuous and often attractively coloured sepals and petals of the flower are, after all, but of small importance when compared with the organs which go to fill up the centre of the typical bloom. We may, perhaps, regard the calyx and corolla in the light of advertising agents whose business it is to spread abroad the knowledge of the existence of the concern which they envelop. As is so well known, the essential organs of the plant consist of the stamens and carpels, these latter forming collectively the pistil. It is the duty of the stamens to produce the pollen



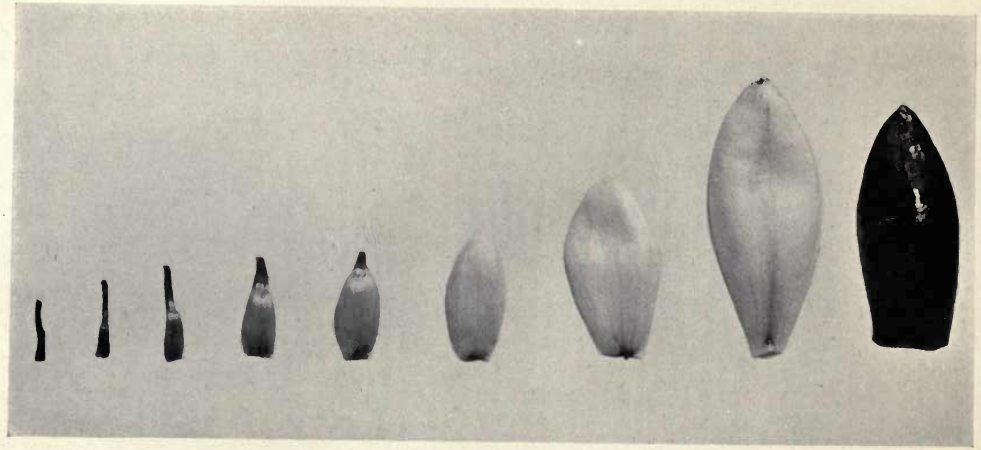
CURIOUS BEGONIA BLOOM.
The stamens in the centre degenerate into petals.

grains, which, coming into contact with the ovules in the female portion of the flower, bring about the process of fertilisation. If all goes well the outcome of this union is the seed—the forerunner of the new plant.

It may not seem to be a particularly easy matter at first sight to determine what may be the origin of the specialised male and female organs of the plant. As we have seen, both the sepals and petals of the flower show a more or less striking resemblance to the foliage of the plant, but one can scarcely say that there is much obvious connection between stamens, pistil, and leaf. None the less is it a fact which can be easily demonstrated that the leaf was the ancestor of even the reproductive organs themselves. In this connection the case of the so-called "double" flowers is very instructive. Here we see that the peculiarity of the blossom consists in a great increase in the number of petals, and these organs must have had their origin in something; as a matter of fact, they are degenerate stamens. The manner in which this change of stamens into petals takes place may be often well seen in the case of Begonias. It has been found to be almost impossible to establish an entirely double strain of these flowers owing to a strong tendency to

revert to a single condition. Very commonly blossoms are to be found in a curious midway stage between the double and single condition, and when this is the case an interesting sidelight as to the connection between stamens and petals is to be seen. Some of the abnormal organs then produced are simply flattened stamens, very much like miniature petals save that the extremity is covered with a deposit of pollen. In other cases there is no pollen at all, and the process is formed of coloured tissue, being in fact a perfect petal on a miniature scale.

Probably one of the most remarkable object lessons to be found in the vegetable world bearing on the origin of stamens is to be found in the case of the flower of the White Water Lily (*Nymphæa alba*). If a well-developed specimen is secured and carefully dissected, it is possible to sort out a most instructive series of organs illustrating the stages between the perfect petal and the normal stamen. Commencing with the outside of the flower, we find the green sepal, which, in passing, it may be pointed out, is partially tinted with white. Next we shall find several rows of well-formed petals, the only strange point about these being that they steadily decrease in size the nearer one gets to the centre. If the investigation



THE RELATION BETWEEN THE PETALS AND THE STAMENS OF THE WATER LILY IS HERE WELL SHOWN.

is pushed still further, it will be found that the petals become even more narrow, until they are strange linear processes which it is difficult to call by any name. At last one will be discovered which appears to be curiously thickened at the point, and if the termination of the organ be closely examined the presence of a small amount of pollen may be detected. The termination of this process, which can be called neither petal nor stamen, continues to be more and more modified as we near the centre of the flower, until it is resolved into two thickened parts, to be recognised as the anthers. When this stage is reached the petal-like lower part disappears and a slender thread takes its place, thus forming the filament, which goes to the making of the typical stamen. In the central rows of stamens it is not possible to discover the least resemblance between the petals and the male reproductive organs.

The Water Lily is not the only flower in which the intimate connection between the petal and the stamen may be traced; something on much the same lines is to be seen in the case of certain species of Peony, and other instances might be cited. It is hardly necessary, however, to bring forward further proof that the relationship

between stamens and petals is a fact beyond question.

It will not be quite such a simple matter to trace in a clear fashion the leaf origin of the pistil as it has been in the case of the three other organs which have been dealt with. It sometimes happens in freak flowers that the stamens are transformed into carpels, and even on occasion strange processes have been found which bear a resemblance to both male and female organs. In the case of an abnormal Saxifrage mentioned by Kerner, it appeared that the anthers and ovules can be produced from exactly the same part of the stalk. There is, therefore, without doubt, a close connection between the stamens and carpels. It is interesting to push the matter still further and endeavour to find out whether we cannot find in a more direct way that the pistil is akin to the leaf.

There does not seem to be any flower in a natural state which offers us a complete explanation as to the origin of the female organs. Even in the case of most double flowers it is not easy to find an instance which helps us to understand the evolution of the carpels. There is, however, one double blossom which lets a good deal of light on to the problem, and this is the Cherry. The

flower will well repay anyone who is interested in the matter to study a little closely. If the inner petals of a well-developed bloom of the double Cherry are torn away, it will be found that a small leaf occupies the place of the usual carpel. This leaf has the two edges folded towards each other, and the midrib is greatly prolonged, having a little knob at the summit. Now if this process be compared with the normal carpel of a single Cherry blossom, it is quite easy to see that the two sides of the leaf represent the walls of the ovary, whilst the elongated process can be none other than the style.

When the carpels have passed their maturity it is not at all an uncommon thing for them to develop into very leaf-like organs. This is the case in the seed vessels of the Pea, where it is discernible that the two sides of the pod are not unlike the lobes of a leaf joined together by a midrib. A most suggestive monstrosity is occasionally seen in the case of the Pea pod. This happens when for some reason the ovules fail to develop and the two sides of the pod do not close together in the normal fashion. When this is the case it is seen that the lobes of the seed vessel are still more leaf-like than is usually the case. Small projections are to be observed along

the edges of this process, which may be called the carpellary leaf, and these will show where under ordinary conditions the ovules would have been.

For purposes of convenience the different parts of the typical flower have been dealt with in the order in which they occur in the actual specimen when a start is made from the outside. By doing so it has been made clear that every part of the flower has a most intimate connection with any other portion. In every case one was brought back either directly or through some other organ to the leaf as the origin of that particular portion of the flower. It is quite certain that the foliage of the plant must have been in existence prior to the blossom, for whilst flowering plants can persist without blooms, they could not live at all without foliage or its equivalent.

The question as to the order in which the various parts of the flower were evolved is a most important one. Though the matter is still controversial, it is sufficiently obvious that the first portion of the flower to be formed could scarcely have been the calyx, the next the corolla, and so on. It cannot be advanced that these organs, which, after all, are only appendages, could have been formed in advance of the reproductive portion. As we have seen earlier, the main object

GLOXINIA

A

of the brightly coloured corolla seems in every case to be the means of advertising the presence of the essential parts of the flower, in connection with the scheme of fertilisation.

Flowers with sepals and petals, but lacking the reproductive processes, are, of course, unknown in Nature, whilst there are many instances in which the corolla is quite absent. One cannot well escape the conclusion that the stamens and pistil were developed from the leaf in the first instance, the protecting calyx and the inner row of petals coming later. If this argument be correct, we should call the midway organs which have been noticed in the Begonia and the Water Lily as degenerate stamens rather than as developing petals.

The subject of the evolution of the flower is a very profound one, and it is not possible to do more than hint at the wonderful process whereby the different parts of the blossom have been developed. To the general observer the most significant point is the manner in which at every turn one is brought face to face with the great importance of the leaf in the economy of the plant. It is in the leaf that the wonderful manufacture of the life basis of the plant—the green chlorophyll—takes place. It is from the base of

the leaf-stalk that nearly all extensions of the plant arise. Not a few plants are able to produce fresh specimens on their foliage, whilst of course many of the low forms of vegetable life increase in no other way than by a system of leaf extension. We shall not be far wrong in regarding the leaf as the most important organ of the plant.

In considering the foregoing instances the student can scarcely fail to have been struck with the importance of those examples which are in some way departures from the normal. Certainly it seems that, as the great scheme of evolution goes forward, the traces of the origin of things become less and less distinct. It will well repay anyone who is interested in the subject to keep a sharp look out for freak flowers; for, as we have seen, it is most likely that in these forms we shall find enlightenment as to the beginnings of the floral organs. The observer will find a much more fruitful ground for observation in the garden or greenhouse than out in the country. It is a well-established fact that under cultivation both animals and plants are much more prone to vary than when they are in a state of nature. We are not very clear as to the reason for this tendency, but the fact is beyond dispute. One of the most remarkable cases which has arisen

as the result of cultivation, having a bearing upon the evolution of the flower, is the variety of Campanula known as the "Cup and Saucer." As in the case of the Gloxinia, the five united petals go to the making of one bell, the five sepals being more or less joined together, but, of course, external to the corolla. In the form under notice it is the joined petals which go to the making of the cup, whilst the broad, flattened-out, abnormal calyx is responsible for the saucer. In this case the sepals have lost their green tinting, and have become blue or white as the colouring of the corolla may be. This is only one amongst many interesting forms which the gardener can find amongst plants which are in general cultivation.

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